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TIMGAD. CAPITAL OF A COLUMN FROM THE CAPITOL.

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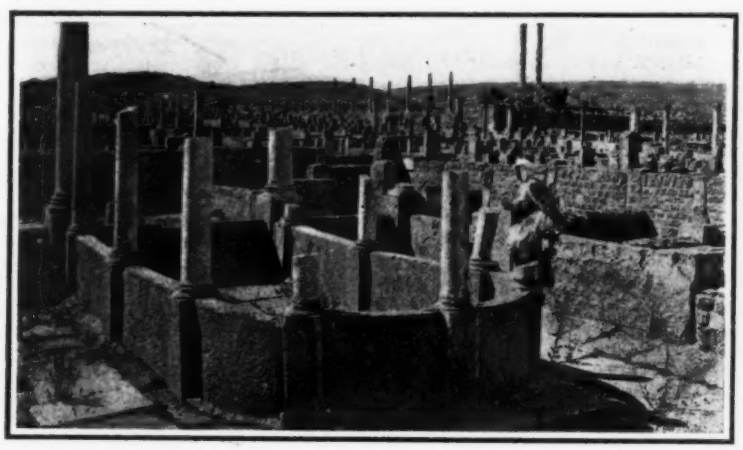


TIMGAD. "HOUSE OF THE BATH-POOL." IN THE BACKGROUND IS THE CAPITOL WITH TWO COLUMNS STANDING.

A STATUE OF AN EMPEROR IN THE ROMAN THEATER AT PHILIPPEVILLE.

A MARBLE STATUE OF ABUNDANCE FOUND IN THE FORUM IN THE RUINS OF TIMGAD.

ROMAN "RUSICADA" AT PHILIPPEVILLE.

NEW FINDS IN THE NORTH AFRICAN REGION.—[SEE PAGE 293.]

THE ART OF ENAMELING.

VITREOUS ENAMELING OF CAST IRON FOR INDUSTRIAL PURPOSES.

BY HAROLD HOLCROFT, M.A., F.R.P.S.

UP to the present time enameling has been treated as a secret process, but seeing that much of the practice of enameling is now common knowledge, the time has arrived when the subject can be discussed by those interested with advantage to all. One difficulty in the way of research which involves any considerable expense, is the fact that the trade is but a minor industry, and perhaps likely to remain so.

Until recently the literature of enameling for industrial purposes only existed in the specifications of patent offices, or in scraps of no great importance in general literature. Silicates are now receiving attention, not only in their application to ceramics and glass, but also to some extent in their application to enamels on metals, and reports thereon are to be found in the transactions of the American Ceramic Society. A summary of recent work in Germany in the field of silicates has been published by Dr. Koerner in the "Sprechsaal Kalender für die Keramischen, Glas-, und verwandten Industrien (Müller und Schmidt, Coburg).

The application of vitreous enamels to cast iron is probably of French or German origin and dates from a time earlier than the beginning of the last century. Tradition asserts that cast iron vessels were enameled in Alsace and Lorraine about this time, and probably also in the Rhine provinces of Germany.

In this country a patent was taken out by Hickling in 1799, and enameled cast iron pots were made under this patent at the Eagle Foundry in Birmingham. This enamel appears to have been applied in one coat and to have contained a considerable percentage of lead compounds. The manufacture was abandoned after a short existence.

In 1839, T. and C. Clark, of Wolverhampton, took out a patent for a process in which the use of lead was avoided. This enamel consisted of two coats; the lower coat being a boro-silicate of relatively high fusing point, and the upper a more fusible glaze. The idea of using two coats, with the upper the more fusible of the two, appears to have originated on the Continent, but Clark's process was a marked advance, in that the quality of the goods was much superior, and the use of lead in the enameling of cooking vessels dispensed with. In the manufacturing process, Messrs. Clark received great assistance from C. Machin, the manager in the enameling department.

Two or three years later, Messrs. Archibald Kenrick & Sons, of West Bromwich, brought out a process upon the same principles, but differing in some important details. As a result of a long lawsuit between these two firms, a compromise was arranged upon equal terms, and to-day both these firms manufacture enameled goods upon the original principle, but of course, with many improvements in detail. Of late years other processes of enameling, differing in principle and composition, are in considerable use in the enameling of baths and various miscellaneous and ornamental articles.

The trade is being specialized and developed for different purposes, but it still continues to be an adjunct or finishing process in several distinct trades. This will in part explain why it is that trained scientific specialists do not appear to be generally employed in the works. The position is unfortunate but not uncommon. If any great scientific development is to take place, it is imperative that the expert should be in close touch with manufacture in bulk, for in no industry is there a wider gulf between successful laboratory experiments on a small scale and manufacture on a large scale which brings to light many important matters which are otherwise overlooked.

The objects of industrial enameling on metals are: 1. To provide a protective coat for the metal against corrosion, either by the atmosphere or anything which may be brought into contact with the enameled article. 2. To provide a smooth surface which may be easily kept clean. 3. To provide a coat which will withstand a wider range of temperature than is possible with any varnish or japan. 4. For ornamental purposes. 5. To provide an insulating covering for parts of electrical apparatus. 6. To provide a hard surface for parts of textile machinery which will not only resist wear from the passage of the material but prevent discoloration from contact with the metal.

The principal articles of commerce in enameled cast iron at the present time are: 1. Culinary and household vessels, which are required to resist the solvent or destructive action of water, saline solutions, weak vegetable acids, weak alkaline solutions, or fatty substances, and may or may not be required to withstand moderate ranges of temperature. 2. Baths, lavatory basins, etc., which more especially should resist the action of soap. 3. Sanitary ware, soil pipes, etc., which are used at normal atmospheric temperatures. 4. Chemical vessels or apparatus which are specially designed to resist different agents. 5. Ornamental articles, some of which, such as the outside shells of gas fires, or other heating apparatus, have to resist a considerable range of temperature. 6. Miscellaneous articles, such as reflectors, insulated electric fittings, and others.

A vitreous enamel is usually a species of glass which is applied to the metal and fused thereon at a temperature ranging from a low red to a bright red heat, but in very exceptional cases the enamel may not contain any silicate at all. In general, enamel consists of a mixture of several silicates or boro-silicates, with the addition of other substances for special purposes. It is necessary for the enamel to have a comparatively low fusing point, since with cast iron the highest permissible limit of temperature at which the enamel shall fuse, must be low enough to obviate the collapse or deformation of the article by its own weight; which temperature will obviously vary somewhat with the shape and weight of the article. It is, however, desirable to have the enamel with the highest permissible fusing point, as the requisite qualities in the enamel are more easily attained than in the case of an enamel of lower fusing point.

In the fabrication and application of an enamel for any required purpose, the manufacturer is confronted with very many difficult problems, one of which arises from the fact that a combination is attempted of two materials of very different physical properties. On the one hand, the metal is a good conductor of heat, has a comparatively high co-efficient of expansion for heat, and is comparatively soft and resistant to shocks; while, on the other hand, enamel is a bad conductor of heat; is hard and brittle, and unless care is taken, has a lower co-efficient of expansion.

In view of the many conditions which have to be satisfied it must be recognized that as no enamel can fulfill every condition perfectly, the best enamel for any particular purpose must be the most judicious compromise of conflicting conditions.

If a chemist is required to report upon the merits of an enameled article, he should especially examine and test it to see if it fulfills the conditions for which it was designed. For instance, in the case of an ordinary enameled saucepan, which is manufactured for the purposes of cooking, the testing to which it should be subjected should be somewhat as follows: Continuous boiling with water for say, fourteen days. If it passes this test it should be subjected to continuous boiling successively for similar periods with weak vinegar, dilute citric acid, dilute solutions of sodium carbonate, and sodium chloride. If the enamel is attacked by these agents, or by boiling water, the polish or gloss of the surface will be replaced by a roughness more or less pronounced and easily seen when any deposits which may have been formed, have been carefully cleaned off. Milk should be allowed to stand in the cold in the vessel for a month, since milk and especially sour milk will attack some enamels which resist the previous tests. The enamel should be tested for hardness, which should be sufficient to resist abrasion in ordinary cleansing operations. The manufacturer's rough testing for hardness is usually performed by scratching with pieces of steel of varying degrees of hardness, which are adopted as standards. The saucepan should then be broken into pieces with a hammer, and it should be noted whether the enamel adheres firmly everywhere to the fragments. In passing, it may be said that by variations in the way of hammering, considerable differences in the result can be obtained. The broken pieces should be examined to see if the coat of enamel is uniform and of reasonable thickness. A good enamel for a saucepan should be somewhat thin. Since enamel is a bad conductor of heat, with a thick coat of enamel the temperature of metal when heated rises much more rapidly than that of the enamel. This sets up strains, which sooner or later do mischief. A thick layer of enamel also considerably impedes the passage of heat to the contents of the vessel, so that by the time the fluids reach the boiling point, the metal bottom of the vessel is at a considerably higher temperature. If, therefore, the vessel be removed from the source of heat, the moment the contents begin to boil, the heat accumulated in the metal bottom of the vessel, will cause the contents to continue boiling for some few seconds. The tendency to boil over is a frequent cause of complaint when the enamel is too thick. The other advantages of a thin enamel follow from a reduction of weight, and do not specially concern the chemist.

Another saucepan should be tested under reasonably rapid changes of temperature, such as are likely to be met with in ordinary use. Water should be raised to the boiling point in the vessel, which should be then rapidly emptied and cold water substituted; repeating this a few times. There should be no chipping or cracking. A more severe test than this is scarcely reasonable for these articles.

Enamel for cooking vessels should be tested by analysis for the absence of lead or other objectionable substances; but with cast iron cooking vessels of British manufacture, it is hardly necessary, as no British maker appears to use any objectionable ingredients in enamels for cooking purposes.

If the enamel appears to be composed of two distinct layers when the broken section is examined, the red ink test should be applied to ascertain if the lower layer of enamel is porous or not. If it is, the red ink will penetrate and will be visible from the upper surface. When the lower layer is porous, any liquid readily penetrates through any slight defect in the upper layer, and causes formation of rust, which sooner or later detaches the enamel from the iron.

The enamel for cooking vessels should be pure white in color, the surface glossy, perfectly smooth and free from defects. Crazing or spider-like cracks, due generally to an error in the expansion co-efficient in the enamel, may be practically invisible at first, but will reveal themselves if the enamel is rubbed with any dark finely divided powder. Any test of a saucepan or cooking vessel with a strong acid or alkali is futile.

In the same way with all other enameled articles, the chemist's tests should have regard to the especial use for which the particular article is designed.

It is found that comparatively small differences in composition produce marked differences in the physical properties of enamels, and in their capacity to resist various agents.

The results of the action of sulphuric acid upon enamel are sometimes curious. In some experiments made to produce enamels to resist this acid, one or two were found which would resist concentrated and also dilute (2½ per cent) acid, for some weeks at least, but at 50 per cent strength, the acid quickly destroyed the vessel. The greatest problem in producing large enameled vessels to resist such agents, is not so much with the enamel itself, as in the difficulty of getting a perfect coat of enamel all over the surface of the metal; the most microscopic fault is fatal.

It is a fact which should be more generally known, that enamels have become highly specialized and different in their composition, physical properties and methods of application. In the enameling of cooking vessels in this country, the industry is a perfectly healthy occupation for the operatives, from the absence of any deleterious materials in the composition, or dust in the working operations. On the other hand, in some of the other uses of enamels, there is need for proper precautions, and Home Office rules, which may be advisable in some cases, are quite uncalled for in others. The same manufacturers do not often produce more than one type of enamel.

Cast iron as a base for enamels possesses one great advantage, in that it forms a rigid support, and the enamel has not to withstand the strains of bending. In this respect it is much superior to sheet iron; but cast iron presents peculiar difficulties to the manufacturer in the application of the enamels. The chemical constitution of cast iron is not a matter of very great importance, except that a high percentage of graphitic carbon is not desirable, as the adhesion of the enamel is lessened. It is also desirable that the plumbago or other facing used in molding the castings should be as small a quantity as possible for the same reason. The most important question in the enameling of cast iron is whether the enamel is to be placed directly upon the natural skin of the casting, or upon a machined surface. Upon the machined surface many varieties of enamel can be applied easily, which would fail entirely if placed upon the natural skin. Enameling upon the natural skin presents special difficulties, and requires special treatment. If

* Read before the meeting of the Society of Chemical Industry held at Birmingham University, Birmingham, England, December 9th, 1909.

the skin of the casting is to be removed, it is most efficiently done either by a lathe or a planing machine or an emery grinder, as neither acid pickle nor sand blast is found to be so effective for the purpose. This necessity in practice tends to limit the application of many enamels to castings of round, elliptical or flat surfaces such as can be dealt with in lathes or in planing machines.

When the skin of the casting is not removed efficiently and an unsuitable process of enameling is used, it will be found that before the enamel has become hot enough to fuse completely, it will, in the language of the enameler, commence to "bleb." That is to say, some action takes place which results in the evolution of a considerable volume of gas, which causes the enamel to blister; and when this happens, it is then impossible to obtain a perfect coat by further heating. The "blebbing" appears to be due to a reaction between the metal and the enamel, but may be due in part also to the liberation of the gases dissolved in the metal. Even when the skin of a casting has been removed efficiently, and a suitable enamel has fused to a perfectly level coat, a further unnecessary rise in the temperature will cause "blebbing" to occur, and in general it may be said of any enamel upon cast iron, that between the temperature at which the enamel will fuse quietly and the temperature at which "blebbing" will commence, there is a somewhat narrow range, and other things being equal, the best enamel is that which has the widest range between these points, because in practice the temperature owing to working conditions cannot be kept within very narrow limits, and "blebbing" means waste and commercial loss.

From their experience in the enameling and tinning of castings on the natural skin, manufacturers are of opinion that metallurgists have much to learn as to the constitution of the skin of castings.

In an attempt to throw some light upon the subject in its bearing on enameling and tinning, I made some preliminary experiments, to test the possibility of producing some considerable alteration in the constitution of the skin of castings. Various facing materials, including steatite, lime and magnesia dust, were tried, and castings were run in red hot loam molds faced with these various materials in an atmosphere of coal-gas so as to exclude free and combined oxygen, but so far the results have been entirely negative. There has been no observable difference in the appearance of the castings, or in their behavior in enameling and tinning.

Preparation of an enamel.—In compounding an enamel for any particular purpose, the enameler usually makes no attempt to produce silicates of any definite chemical constitution, but follows such empirical rules as his experience may have taught him to accomplish his objects, and probably he is right. The preparation of an enamel must not only have regard to the physical properties required in the finished enameled article, but must also conform to the qualities necessary in the enamel in the act of fusing upon the article; some of which are: Temperature at which the enamel fuses; range between the fusing point and the temperature at which "blebbing" will take place; viscosity; surface tension.

The fusing point of an enamel is usually controlled by the proportion between the alkaline bases and the silica; by the use of borax, boric acid, or in some cases by lead compounds, but an undue proportion of alkaline bases or borax tends to produce softness and solubility of the enamel in aqueous solutions.

The difficulty as to "blebbing" has been alluded to and must be lessened by experience and skill in producing the enamel.

As regards viscosity in the enamel in the fused state, a high degree of viscosity is especially desirable when it is necessary to prevent the fused enamel running down any vertical surfaces of the castings; on horizontal surfaces it is, of course, not so important. Silicate of alumina is one of the components which is frequently employed for this purpose, but it has also a tendency to raise the melting point, which must be re-adjusted. Barium silicate is sometimes used when it is desired to reduce viscosity, but this has a tendency to lower the melting point of the enamel.

A high degree of surface tension is generally desirable in the enamel in the fused state, as it is the play of this force at the moment of fusing which stretches the enamel to a level smooth surface. It is possible, however, to have the surface tension too high. At the moment of fusing, the force of adhesion between the enamel and the metallic surface, or between the enamel and the under coat, as the case may be, should be considerable; that is, the fused enamel should "wet" the surface. There must be a proper balance between the forces of adhesion and surface tension. If the adhesion is not sufficient, the surface tension will cause the melted enamel to run up into isolated globules.

In the making of an enamel, the materials, in a fine state of division and well mixed, are fritted or melted in crucibles or reverberatory furnaces. The temperature of the furnace and the length of time in the furnace are important. Possibly the silica and the various bases arrange themselves differently at different temperatures; at all events the furnacing of the enamel materials may produce considerable differences in the physical properties of the enamel. The adjustment of the co-efficient of expansion for heat does not usually cause much trouble, as the enameler has his well-known formula and method which generally turns out right. But when something goes wrong, or when an enamel is required to comply with certain new conditions which may have been successfully met, except that the expansion co-efficient is too high or too low, it becomes necessary to correct the expansion co-efficient. There are several ways known to enamelers of doing this, but it is the case with most of us, that we cannot express even in approximate figures what will be the result of any given correction we may make. We do not even try to measure in figures the co-efficient of expansion; all we know is that we must adjust it to that of cast iron, viz., to 0·0000112 per degree Centigrade (0.00002016 per degree Fahrenheit), as measured between 0° and 100° C. (32 and 212 F.); and we do the adjusting by trial and error. Perhaps in the case of a saucepan, it would be better practice to make the expansion co-efficient of the enamel rather higher than that of cast iron, since the enamel in contact with a fluid would rarely rise quite so high in temperature as the outside of the vessel while in contact with the source of heat. The subsequent cooling is a more gradual and equable process, and not likely to set up sudden local strains.

Grinding the enamel.—Enamels are applied to the metals in various ways, wet or dry; but in all cases it is necessary to reduce the enamel to a ground or powdered state, to permit of distribution in an even layer. The degree of fineness to which an enamel is ground or powdered is important. In the wet process, the enamel must be fine enough to remain in suspension in water for some time, but grinding too finely appears to affect the expansion co-efficient for reasons which are not easy to see, and the result is what is known as "crazing," i. e., very fine cracks in the enameled surface. Ideal grinding generally consists in obtaining all the particles of enamel of the same size; but in some ways of applying the enamel, it is an advantage to have a mixture of fine and relatively coarse particles. Grinding in the wet way is accomplished in mills lined with French burrs, with runners of the same material, or in horizontally rotating cylinders lined with hard porcelain and partially filled with glass balls or flint stones. With the mills, the large surface of the runners moving uniformly over a large number of particles of enamel tends to reduce them all uniformly in size, and is the best system where the enamel is required to be of any given degree of fineness, except the extremely fine; although this can be attained by prolonging the time of grinding. The cylinders, on the other hand, are best when the enamel is to be ground extremely fine. The actual surface contact between the glass balls or flints is so small that the pressure per unit of area is great and some of the enamel is at once reduced to extreme fineness, while the remainder is comparatively coarse. For fine grinding the cylinders are not only better but rather quicker, and the materials are not exposed to contamination from dirt.

For reducing enamel to powder in the dry way, edge runners of granite on a granite base are used, sometimes an ordinary French burr mill.

In all the foregoing methods every care is taken to prevent contamination by metallic particles or organic matter, which gives rise to defects in the enamels. In some of the coarser forms of enameling where the specks and stains due to metallic particles do not matter, edge runners of cast iron or ordinary stamps are used.

Application and fusing.—When the enamel is used in suspension in water as a cream, it is ground finely with a small percentage of china clay, magnesium sulphate, or other agents to increase the specific gravity and viscosity of the cream, so as to keep the enamel in suspension longer, and to facilitate the operation of flowing the cream over the surface of the article to be enameled in a uniform layer of the desired thickness. After drying, the enamel is ready for firing.

When the enamel is applied in the dry state it is not so finely powdered, and is distributed with the aid of a sieve, or in other ways, over a surface coated with gum, or direct upon the red-hot surface of the cast iron, either the bare metal or coated with a first coat. In the latter case the metal carries enough heat to fuse the enamel immediately it falls upon the surface, if the operations are carried out quickly, and the enamel has a low enough fusing point. It may or may not be necessary to return the article to the muffle to produce a perfectly fused surface. In some cases a combination of the wet and dry methods is used; and two or three coatings may be given of the same or different enamels by successive firings. When several coats are used, it is nearly always an advantage for the lower coats to be less fusible than the upper. When different enamels are superimposed, it is of course necessary that their co-efficients of expansion agree; and that they are otherwise a suitable combination.

In the firing of an enameled article in a muffle, the enamels are partly protected against the furnace gases, but not altogether. Some enamels will not stand the action of the gases for long without deteriorating, and must be removed soon after complete fusing. With castings of uniform thickness, which rise in temperature equally all over the surface, this presents no difficulty, but in the case of a casting, especially a large casting, which has thin parts and thick heavy parts, the heating is irregular, and the enamel upon the thin places is liable to be fused and spoilt before the enamel on the thick parts is melted. Such work is difficult and requires great experience.

When an enameled surface is produced by two coats, the lower of which is a boro-silicate or other mass of comparatively high fusing point, and the upper a more fusible glaze, some considerable advantages are gained, one of which is that an enamel which could not be used direct upon the metal surface, can be used as the upper coat. Another advantage is that when necessary the enamel may remain longer in the muffle without damage; this is important with irregular or heavy castings. This method, however, requires accurate adjustment of the enamels, and special care in the operations, otherwise the lower layer may remain porous, so that liquids will rapidly penetrate by capillary action, as soon as there is the slightest flaw in the upper surface. The lower layer must at least soften sufficiently to form a solid mass, or the upper layer must penetrate the lower layer and fill all porosity.

White enamels.—Colored enamels are produced much in the same ways that are adopted with glass or pottery, and scarcely require comment, except where the enamel is a more or less opaque or translucent white. There are several ways in use for producing the effect of a white surface. (1) By mixing with a transparent enamel some opaque white substance which does not enter into combination with the enamel, but remains as a mechanical mixture. Oxide of tin is an example. A specially pure and finely divided oxide is prepared for enameling, and is introduced at the latest possible stage, so that the mixture of enamel and tin is heated as little as possible, otherwise the oxide of tin will enter into combination with the silica with a partial or total loss of opacity. In the application of the wet method the oxide of tin is often added to the enamel within the mill and the two are merely ground together. Bone ash is probably another example. (2) Cryolite, or other fluorine compounds, with some enamels will produce a translucent white. Apparently the effect in these cases is due to the production of minute crystals having a different refractive index to the rest of the enamel. Overheating causes a loss of opacity which partially returns on cooling. (3) A white color may be produced by coating a transparent or opalescent enamel upon a white ground layer of a boro-silicate, or other mass of a comparatively high fusing point. The lower layer does not fuse completely, but softens sufficiently to adhere to the surface of the metal, and supplies an opaque white ground, while the upper layer of enamel furnishes the smooth and glossy surface. (4) The effect of a white color can also be given by the production of excessively fine air bells in a transparent enamel. In this case considerable viscosity in the enamel is necessary, otherwise the air bells coalesce with a loss of opacity.

Pinholes, a common trouble of enamelers, are "solutions of continuity" of the surface of the enamels in the shape of small round holes. They are due to several causes: (1) Presence of fine particles of organic matter which are allowed to get into the enamel for the upper coat. Splinters of wood ground up with the enamel are a common source of trouble. These minute particles of organic matter become decomposed with the heat of the muffle and form small bells of gas, which either remain as such, or burst and form holes in the enamel which frequently will not close up. (2) Microscopic fissures or holes in the casting, the air from which expands by heat and forms air bells in the enamel. (3) "Blacks," that is, slag or scum in the skin of the castings, which produce bells of gas by re-action with the enamel. (4) Imperfections in the first coat of enamel which expose the metal to the attack of the upper coat of enamel. (5) Particles of foreign matter or spots due to imperfect preparation in the first coat of enamel where the force of adhesion is less than the rest of the surface; these result in spots which the upper layer of enamel will not cover.

Principles in application of enamel.—There are at least four well-defined different principles in the application of enamels to cast iron.

1. That embodied in Clark's patent, viz., an under

coat of considerable thickness, with a relatively high fusing point: this is applied in the wet way, dried and fired, and an upper coat of enamel of a lower fusing point added.

2. A very thin special under coat is applied in the wet way, dried and burnt right into the surface of the iron. There is then scarcely any visible coat, but the surface of the iron is affected so that the propensity to "bleb" is retarded, and an ordinary fusible upper coat can be added.

3. A moderately fusible enamel is applied in the wet way direct upon the surface of the iron, dried and fused.

4. One or more coats of very fusible enamel are applied as a dry powder direct upon the red-hot surface of the metal.

Methods 1, 2, and 4 can be used either upon the natural skin of the casting or the machined surface. Method 3 as a rule can only be applied upon a machined surface, although with a few enamels it is possible to coat upon the natural skin. It is not a matter of indifference which way any given enamel may be applied.

It has been recommended to submit the casting to the Bower-Barff process as a preliminary to enameling. In my own experience I have not found any special advantage in this, while the extra cost has been a serious commercial handicap.

To satisfy many of the conditions laid down in t paper, either singly or together, is not so difficult, b to satisfy all of them at the same time is difficu and sometimes impossible. It is to be hoped th enamelers will abandon their habit of attacking pro lems single handed, and will combine among the selves, and with trained chemists, seek to place u a different footing an industry which if it is destin to remain a minor one, is at least of absorbing i terest.

In conclusion, I have to express my acknowle ments to Sir William Kenrick, Sir George Kenri and Mr. C. F. Clark, for information in this paper. Journal of the Society of Chemical Industry.

MODERN STEREOTYPY.—II

THE MECHANICS OF THE NEWSPAPER.

BY HENRY A. WISE WOOD.

Continued from Supplement No. 1791, Page 282.

THE printing machines of the present day are composed of many printing-couples, the products of which are gathered, folded and delivered by one or more folding machines. A printing-couple is composed of the plate-bearing printing cylinder and its co-operating blanket-covered pressure-cylinder. It is by the latter that the web is borne to receive the impress of the type. A four-couple press of four pages in width has usually two folding machines, or "folders" as they are called. The normal speed of the modern folder being 24,000 newspapers an hour, such a press may be run at the hourly rate of 48,000, four, six or eight-paged papers. Or, if its two webs are split and the parts from one side are transferred over and combined with those of the other, and all are run into one folder then, as but one folder is being used, the number of pages of each newspaper produced may be doubled, but a production of but half the number of newspapers will be possible. Thus 10-, 12-, 14- or 16-paged papers may be produced by a four-couple press, which is technically known as a Quadruple, or "Quad" machine, at the rate of 24,000 copies. A machine having six printing-couples, known as Sextuple, or "Sex," by using two folders is capable of all the combinations of a "Quad," but by using an additional web is able to make 10- and 12-paged papers at the rate of 48,000, and 18-, 20-, and 24-paged papers at the rate of 24,000, an hour. An Octuple, having eight printing-couples and using four webs is capable of turning out products of 14 and 16 pages at the greater rate, and of 26, 28, 30 and 32 pages at the lesser rate, of speed. Octuple machines usually have four folding mechanisms and thus are able to attain a rate of output upon products having eight pages or less of 96,000 copies. There are, also, machines in use having twelve printing couples; while still others, known as Double Octuples, have sixteen. With collecting mechanisms at work in each case a product of double the number of pages may be obtained; but at half the full rate of production. Competition has recently driven the manufacturers of newspresses to rate their machines higher in speed than that mentioned, but as no essential change has been made in the mechanisms employed little real gain in the actual hourly average of product has resulted. It should be understood that the rates of output cited are merely "indicated." In practice the speed of two hundred turns of a press-cylinder per minute which, if continued for the hour, should produce with one folder 24,000 copies, actually results in but from 16,000 to 18,000, more or less. A press must be stopped when each of its web-rolls expires and resupplied with paper, which greatly reduces the number of minutes run in the hour, and paper-breakage, a frequent source of trouble and delay, still further reduces its output.

In the foregoing description of the development of the modern newspress, I have not thought it necessary to refer to the transitory forms of machines which have occasionally appeared, but have deemed it sufficient for the purpose of this lecture to trace the main stream of progress along which the machine of to-day has come.

From the foregoing it will appear that the newspaper now depends upon the co-operation of three important mechanical departments: The composing room, the stereotyping foundry, and the press-room. Having shown how the newspaper is "set," and how it is printed, I shall now take up the indispensable link which connects the two. This brings me to the main subject—Stereotypy, Old and New. In order to illustrate the great importance of the art of stereotypy I shall set before you the images of two newspaper offices, the one without, the other having, the advantages which stereotypy confers. In the first the type clamped in curved frames called "turtles," may be used upon but one press. The turtles having been secured in place and the machine started, in the course of an hour's time 10,000 copies, or at most 20,000, are produced and distributed. How little such a puny output could satisfy the needs of the present day will appear when it is known that the circulation of many evening papers is now about three hundred thousand copies, and that there are some that closely approach to half a million. My second image need be nothing more than that suggested by the statement that in a modern metropolitan newspaper office will often be found combined in one form or another from forty to sixty complete perfecting printing mechanisms; and that within twenty minutes after the arrival at its stereotyping foundry of the last page of type all of its presses fully supplied with printing plates will be turning off newspapers at the speeds I have mentioned. The importance of the art of Stereotypy is plain when it is realized that by means of it a plant containing sixty press-units is now possible, and that such a plant is capable of producing the equivalent of from seven to ten hundred thousand eight-paged newspapers an hour. Thus it will be seen how vastly it has multiplied the productiveness and therefore the usefulness of one of man's greatest mechanical discoveries—type.

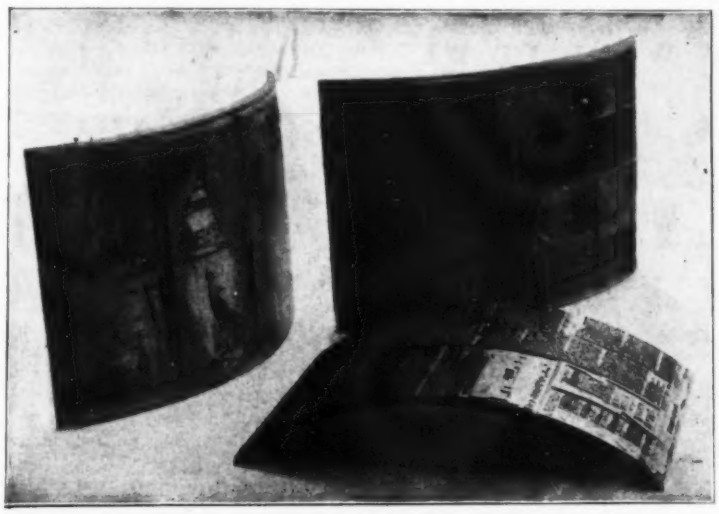
In the year 1890 I first became interested in the art of Stereotypy, which was then being practised exclusively by manual means. But a few devices, power-driven and hand-controlled, had been provided to

THE AUTOPLATE CASTS FOUR 50-POUND STEREOTYPES A MINUTE

Saves $500 a week in operating expenses and enables pages to be held open longer.

*Read before the Franklin Institute.

facilitate its work. One was used to remove the riser or sprue of the freshly cast plate, while another, when a plate had been dropped into it by hand, served to smooth out the plate's inner, or seating, surface. In but one other function was the work of the hand assisted by power. The moist papier-maché sheet, or "flong," as it is called, after it had been laid upon the



CURVED STEREOTYPE PLATES READY FOR THE PRESS.

type page and covered with a felt pad, was molded to the face of the latter by an iron roller beneath which it was drawn upon a bed propelled by power. Excepting these, all of the operations of stereotyping required the direct employment of the thought, the eyes, and the hands of workmen.

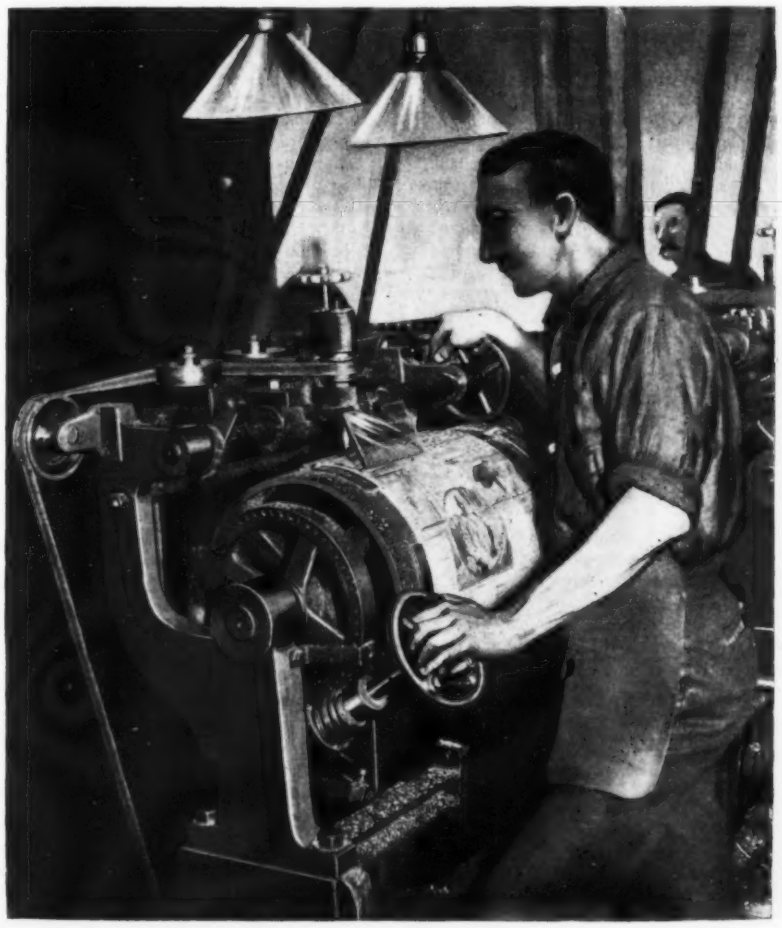
The process of stereotyping then in vogue may briefly be described as follows: To prepare the flong two blotter-like sheets of paper were pasted together, and upon one side of these four sheets of close-fibered rice straw tissue were pasted. The paste used, its composition then a trade secret, was of flour, a clay, and a germicide, the latter to prevent fermentation. Flongs enough were made for the next day's requirements, and these were allowed to season in a moist place. As each type-page reached the foundry a flong was laid upon it, tissue-side down, and upon the flong a closely-woven stout felt blanket. Page, flong and blanket were then run beneath an iron roller, the operation of molding thus being performed. Before the advent of the molding-press, the flong was beaten into the face of the type-page by long-handled brushes; a slow process, which the roller superseded. From the molding press the type-page with its molded flong (now become a matrix) still clinging to its face, was carried to a steam-heated iron table where, the molding blanket having been exchanged for several layers of dry soft blanketing, an unheated iron plate or "platen" was screwed down upon it. Heat, thus applied to the type, drove all moisture from the matrix into the blankets and usually in from four to six minutes the matrix, or "mat" as it is usually called, became dry and was ready to be cast from. In the eighteen years that have since elapsed this process of molding and drying has undergone but a slight improvement. Better paper and paste have increased the durability of the matrix, and an improvement in technic has made it more sensitive to the delicate "effects" of modern illustrations; but, if a slight reduction of the time consumed in its making be excepted, the process of matrix-making has scored no substantial gain. Of progress in the making of plates, however, a different story is to be told.

When stereotyping was first adapted to newspaper printing, certain implements were necessary in order that suitable printing plates might be made. The employment of the rotary press required that the plates be curved. It was also requisite that they be of uniform thickness, and that their curved ends be beveled so that they might be held by clamps to the cylinders of the press. These conditions necessitated the use of a curved casting-mold, or "box" as it is called. In this the paper matrix was bent and clamped. The mold was then closed, a hinged semi-cylindrical core acting as cover, and into it a ladleful of molten stereotype metal was poured, by two men who had fetched it from a nearby caldron. After the appropriate time for solidification had passed the mold was opened and the casting, with its clinging paper matrix, removed. Then the delicate operation of stripping the matrix from the face of the cast was cautiously performed, and the matrix was returned to the mold and repositioned for another cast. Meanwhile the first cast was placed upon the cylinder of a "cutting-off" device where, after having been nicely positioned and securely clamped, it was turned beneath a power-driven rotary saw and its riser, or rough upper end, removed. The saw of this apparatus was so shaped that it left the curved edge of the cast beveled. The cast was then turned and its other end passed beneath the same saw, in order to insure to it likewise a satisfactory clamping surface. The cast was then inverted and dropped face-down into the hollow of a "shaving-out" device, in which a rotating straight-edged knife served to smooth or plane its inner surface, and to give it an accurate thickness. In order to reduce the surface thus needing to be planed it was customary to construct the core about which the cast was to be made with narrow circumferential grooves, set an inch or so apart. In the casting operation these grooves were reproduced upon the inner surface of the cast as ribs, or finishing strips, and furnished a surface which, when planed, was ample to support the cast plate under the pressure of printing. After it had been shaved the cast was next set, face up, upon a fixed cylinder, or "horse," where two men, with hand-plane and chisel, removed from its edges all superfluous metal, which might otherwise take ink and print. This was called "finishing." From the finishing horse the cast plate was next carried to a trough and cooled, and thence to the press-room where it was dried and clamped to the cylinder of a press. All of these operations, save only the propulsion of the cutting-off saw and shaving knife, were performed by hand. And for each plate made every function, from the precise positioning of the matrix to the drying of the finished plate, had to be repeated.

The casting mold was a heavy and clumsy piece of apparatus, which consisted of back and core, a bottom "ring," beneath which the lower matrix-edge had to be clamped, two side-bars which had then to be laid upon the straight sides of the matrix to hold it in position, and clamps for finally locking the halves of the mold together before it should be stood on end to be filled. Two men were required to insert and position the matrix, and put the mold together, and likewise to take it apart after its contents had cooled, and remove the cast and matrix. Another man was required to cut off the riser, a fourth to shave the plate, a fifth and a sixth to "finish" it, and still another man to dip it. The rapidity with which such a crew could work, with a single casting mold, was at the rate of a plate in every minute and a half. Thus in order to produce ten plates from a matrix, or enough to suppy five quadruple presses with the plates required to enable them to print a single page, from fifteen to twenty minutes were consumed. If, in an office having five such presses, an eight-paged paper was to be run, eighty plates had to be made, the casting and finishing of which consumed nearly two hours, if but one casting box were used, or half the time if two, as was the custom, were employed.

As the circulations and bulk of newspapers increased, presses and pages were added, until at last the one hundred-odd paged Sunday issue, produced in a press-room having no less than sixty unit printing mechanisms, each requiring perhaps sixteen printing plates, ceased to be a rarity. As its pages and presses grew in number, so also did the stereotyping plant of a newspaper in the number of its men and pieces of apparatus. And at last the pressure of plate-making became intolerable in the offices of the large metropolitan journals. Nevertheless, up to the close of the last decade of the last century, the process of stereotyping was carried on in the primitive manner described, and entailed the performance of hard manual labor under injurious conditions of temperature and haste.

The accompanying illustrations of the hand-worked process of plate-making exhibit the principal operations to which I have referred, and are representative of the most advanced state of the art when, in 1900, the Autoplate machine was first set to work in the



ROUTING CURVED STEREOTYPE PLATES.

office of the New York Herald. Perhaps the most concise summary anywhere to be found of the nature of the change effected by the introduction of machine stereotypy, is in the following extract from the New York Herald itself: "The third department of newspaper mechanics—stereotyping—has remained almost at its starting point, one of the few arts still in the

realm of hand labor. It is twenty years since the last improvement was made, and now, in the last year of the century, the art is raised to the mechanical level of its sister arts by Mr. Wood's invention, which does automatically, with few men's hands to aid it, what formerly required many hands and fourfold the expenditure of time. Thus, in the closing year of the nineteenth century the last act of the mechanizing of the printing trade has been accomplished. First came the rotary press in 1860, then the linotype in 1888, and now the autoplate in 1900.

(To be continued.)

THE BATTLESHIP OF THE FUTURE.*

WHAT WILL IT BE?

BY REAR ADMIRAL R. H. S. BACON, C.V.O., D.S.O., ASSOCIATE.

THE battleship is solely a gun platform. The gun is, at the present moment, the main weapon in deciding naval actions; therefore progress in battleship design has been continuously in the direction of increased offensive gun power, and defensive armor protection against gun power. The development of gun power has followed closely upon the improvements in the manufacture of steel. The cast gun with spherical shot was superseded by coil guns, rifling, and pointed projectiles. The restriction of the chamber pressures which could be allowed in the early days involved low muzzle velocities and short range. Improvements in propellants and strength, and more reliable material for construction, have increased the length of range, and led to longer guns and higher pressures. The result has been that the accuracy of the gun to-day at 12,000 yards is considerably greater than the accuracy of the gun of thirty years ago at 2,000 yards. At the present moment the development of the gun shows no signs of abating, and there is every reason to believe that, if required, the power of the gun can, within the next few years, be considerably increased. The first important questions in design are: Is such an increase necessary? What advantages would it confer, and what disadvantages would it entail? To consider these, we must examine the second feature of a battleship—namely, its defensive armor.

The distinctive feature of the battleship over the cruiser is that, in the battleship, speed is sacrificed for defensive armor protection. This armor is disposed with its greatest thickness in the belt, gun-positions, and conning-tower, so as to protect those portions which are vital, so far as maneuvering and gun-fire are concerned.

There is no doubt that the gun of the present day can, with armor-piercing projectiles at a range of about 6,000 yards, penetrate any armor which can be practically mounted in a ship, and guns can be built which can penetrate this armor at ranges outside which it would be practically impossible to bring a fleet action to a decisive conclusion. Therefore, if anything approaching modern design of battleships is to be adhered to, it is perfectly hopeless to think of attempting to supply armor which would be impenetrable to any guns which may be constructed in the reasonable future. If such a thing were attempted, we would have to return to the shape and speed of the old "Inflexible." Moreover, if such a ship were constructed, and impenetrable armor provided, the racking entailed by successive hits of heavy projectiles would cause such a general leakage as to leave the ship little better off than if the armor had been penetrated.

This race between gun and armor, which has been going on for over half a century, is being decided for the moment in favor of the gun; nor is there any indication of there being a chance of improving the armor, and strengthening general construction so as to render ships reasonably immune from armor-piercing projectiles. So far, therefore, as regards mere perforation of armor with armor-piercing projectiles, there seems to be no immediate necessity for increasing the power of the gun.

The armor-piercing projectile, however, is not the most efficient shell for effecting general damage on a ship, and penetration of armor is not the sole object of gun-fire. The chief damage will probably be done by heavy bursting charges. The heavier the bursting charge, the greater the damage inflicted by each individual hit. There can be no choice, so far as damage is concerned, between a large burster and a small one, and therefore, from this point of view, the larger the gun, and the larger the projectile, the better. Again, accuracy in the performance of a gun can be best obtained by development of the gun and projectile in reasonable proportions. With power-worked mountings the rate of fire need not be reduced as guns increase in size, and therefore the desirability of rapid hitting, and effect of the hits when obtained, both point to steady increase in the size of the guns. The sole limitation as regards progress in the size of a gun carried is the increase in displacement necessary.

If the gun is to be increased in size on the same displacement one of these three things must happen; (1) The number of guns must be reduced, or (2) the armor protection must be reduced, or (3) the speed must be reduced.

The extra weight required for the guns must be obtained from one of these three sources. We therefore find that while accuracy and efficiency point to increase in size of gun, this increase must be obtained at a sacrifice.

First, as regards displacement. It has often been said that our ships are too large, and as regards this there are two distinct issues: (1) Finance and expediency. (2) Efficiency and utility.

The chief argument against size is the enormous cost of each ship, and, therefore, the large loss in case of sinking. Another argument is that our harbors are already too small, our docks require enlarging, and the ships become too large to handle in fleets. As regards the first of these arguments, the whole crux of the question seems to lie in the consideration as to whether a large ship or a small ship is more likely to be lost from the attack of a torpedo. Constructionally, there seems no doubt that the larger the ship, the more likely she is to survive the blow of a torpedo. Surviving, however, is not the sole point. Damage by a torpedo will temporarily incapacitate a ship, however large she may be, and, therefore, a bigger money value of fighting appliance will be temporarily incapacitated by a single torpedo attack in the case of the large ship than in the case of the smaller; but the smaller ship may sink, and the loss become permanent. This question, therefore, resolves itself into one of time of repair. Provided, therefore, the number of ships are kept constant, although their size is increased, no danger from the torpedo accrues to the country by building larger ships. The matter, from this point of view, becomes one of the national purse, and whether, while retaining *pro rata* numbers, we can afford to build bigger ships.

There are, however, many who uphold the view that they prefer a larger amount of smaller ships to a less number of large ships, and that the money devoted to naval construction would be better spent upon numbers than upon size. The features of this contention require careful consideration. It must be assumed that an equal sum of money is spent in either case. The smaller-sized ships involve carrying fewer guns, or a mixed armament of heavy and lighter guns, both of which are adverse factors to hitting at long ranges.

The most modern type of battleship at present constructed is represented by the "Dreadnought" class, and the improved succeeding vessels. Of course, it is well known that the chief features of the "Dreadnought" are the installation of an all-heavy caliber armament of the heaviest nature, accompanied by increase in speed. Whatever arguments have been raised against this type have been proved, by subsequent experience, to have little weight with European navies, since all have, to a large extent, adopted the principal features of the "Dreadnought." It was only to be expected that the sudden transition from the "Lord Nelson"—or, really, so far as general knowledge in the navy and the country was concerned, the "King Edward" type—to the "Dreadnought" was certain to evoke criticism and comment. The directness that characterized the Admiralty administration of that period swept aside all compromise, and designed a ship with no guns of any sort except the 12-inch and 12-pounder, the latter being then considered the most suitable for dealing with destroyers.

The main reasons underlying the abolition of the secondary armament were, first, that these guns tended to reduce the accuracy of hitting of the heavier guns; and, secondly, that the weight, and therefore the extra tonnage that the installation demanded, could be better devoted to other purposes. The contention as regards accuracy of hitting has been well borne out by subsequent experience. Without entering into any technical reasons—and the argument is very highly technical—one point can be easily appreciated, and that is, that when the undivided attention of those directing the fire of the guns is concentrated on one type of gun only, it is far easier to correct the fire of the guns efficiently than to correct the vagaries of three calibers of guns, of varying rapidity of fire and of varying external ballistics, all of which are firing at the same object.

It must be appreciated that a 6-inch gun at long range is of no use at all against thick armor, and against the lighter armor and superstructures the small burster of the light weight of the shell militates against much real damage being done to the ship, even by a large number of such projectiles. It is held that "a hail" of such projectiles is liable to damage communications, etc. This might possibly have some weight, provided that "the hail" really exists in practice, or that, if it exists, "the hail" hits the ship. As a matter of fact, when gun-fire is handled so as to attempt to obtain hits, rapidity of fire falls very much below the possible rapidity of fire of the gun, and the actual rapidity of fire may easily fall to a quarter or less of the possible rapidity. In fact, when the fire of a quick-loading gun at long range is intermixed with other guns, rapidity of fire falls off very considerably, since it is now appreciated that rapidity of fire, unaccompanied by rapidity of hitting, is a futile waste of ammunition. It is generally considered that 6-inch fire at ordinary battle range may be discounted when accompanied by a 12-inch gun-fire.

There are, however, a considerable number of people who hold the view that battles will not always be fought at long range, and, therefore, in thick weather, the smaller guns may more nearly approach their theoretical value. It is perfectly possible that battles may be fought at moderate ranges; but it must not be forgotten that the accuracy and rate of fire of the heavier guns is also increased *pro rata* at such ranges, whereas the actual effect of the bursters and fragments of the projectiles at these ranges is not greater than at the longer ones, and that the damage occasioned by small projectiles is in no way comparable to those of the heavier type of guns.

If it were possible to install guns of this nature in a ship without either restricting the fire of the heavier guns or of unnecessarily increasing her displacement, and if it were thoroughly understood that they were only there to be used in thick weather, there might be some advantage in installing them. The difficulty, however, of such an installation is very great. If placed below the tier of heavy guns, their position comes very close to the water; if placed on a level, they are bound to reduce the arc of fire of the heavier guns; and if placed above them, they involve considerable top weight, since, wherever they are put, if they are to be of value in a fleet or single ship action, they must be protected by adequate armor. The futility of installing any guns for use in an action unless they are adequately protected against gun-fire is apparent. If the fighting-power of the ship with a mixed armament is to be kept the same as that of a ship with a single-caliber armament, the small gun must be in addition to the large ones. The question of the installation of such guns is, therefore, purely one of whether the designers consider the extra tonnage to be worth the advantage that may accrue. Up to the present, those responsible for the construction of our ships appear to take the view that the advantage is not worth the extra displacement.

The question of mounting an intermediate type, such as the 9.2-inch or 10-inch, as well as the heaviest type, is slightly different, since these guns have a projectile more capable of inflicting damage at long range; but when the disadvantage of a dual armament is considered, in conjunction with the comparatively small amount of weight saved, and the small increase in rate of fire obtained practically by mounting such guns, instead of an additional number of heavy guns, there is not much doubt that in the future the single heavy armament will carry the day.

There is one other aspect as regards the mounting of 6-inch guns, and that is from the point of view of those guns being used merely for anti-torpedo boat guns. This is advocated by those who look on the 6-inch gun as a better anti-torpedo boat gun than the 4-inch. This is purely a matter of opinion, and there is a greater excuse for mounting 6-inch guns for this purpose than for use in an action, since it does not involve the necessity of providing them with armor

* Read at the spring meeting of the fifty-first session of the Institution of Naval Architects, March 16th, 1910 (condensed).

protection. Their use would then be largely confined to defense against torpedo craft before the day of a general action arrived, and for this purpose they require no armor protection. It is not likely that after a general action with the present-day heavy ordnance, these guns, whether protected or not, would survive to be of much practical value.

One point, however, must not be forgotten, and that is, that the possibility of mounting 6-inch guns in future ships sets a low limit on the thickness of armor belt, since it would obviously be foolish to reduce this to an amount which would allow these small guns to effect penetration at battle ranges, and, therefore, to lay the ship open to vital attack by small guns.

In building the small ship, speed, size of gun, and power of each hit are sacrificed. Moreover, the length of the line of battle is considerably increased. The fewer the guns mounted in each ship, the larger the number of ships that will be required for an equal number of guns; therefore, the larger number of intervals between the ships, and an equivalent increase in the length of the fighting-line. This is, further, a very important consideration when the question of the use of the torpedo during an action comes to be considered.

As regards the size of our harbors, we have still plenty of places where we can berth ships 100 per cent larger than the "Dreadnought," and without real inconvenience. Size is by no means the only inconvenience in handling a ship in a close harbor, and from practical experience I can vouch that the "Dreadnought" was, from every point of view, more easily handled in a close harbor than the "Irresistible," whose tonnage was 50 per cent less. It must also be remembered that increase of the size of ship in comparison with the size of harbor may be met by a development of methods and of auxiliaries such as tugs. As regards depth of water, although certain harbors may be less convenient than others, we have still plenty that can be used, even if greatly increased draft becomes a necessity.

As regards maneuvering with a fleet, no greater libel was ever published than the statement that the "Dreadnought" could not be maneuvered satisfactorily with the fleet, and any naval officer of experience who is not an automaton would find no difficulty in handling vessels of 50 per cent greater tonnage, even when in company with the lighter class of battleships. The fact that the "Dido" class were about one-third the tonnage of the "Bulwark" did not prevent their safe handling when in company.

The use of the torpedo during a fleet action can no longer be neglected. The improvements of late years in this weapon have been considerable. It has been very much the fashion up to date to disregard the possible developments of this weapon. There is no doubt that of late years in America, on the Continent, and also at Messrs. Whitehead's, there have been introduced improvements into the torpedo which have totally altered the character and use of that weapon. It is not improbable that these improvements are merly in their infancy, and that before many years has elapsed we may find ourselves confronted with a weapon of considerably greater powers. If the range of the torpedo can be brought up to 6,000 yards, it has great possibilities in an action. There is no doubt that it is far easier to hit one of twelve ships with a torpedo than to hit a single ship aimed at, and therefore the longer the line of ships, and the greater their numbers, the more vulnerable they will be to attack by destroyers at long range in an action. This is an additional argument in favor of increasing the size of individual ships rather than the number of ships in the line.

As regards retention of the present thickness of armor protection, this is a matter which may, before long, undergo considerable modifications, and the armor problem of the future appears to resolve itself into the answer to the following question: Supposing the guns of the enemy can with certainty pierce armor protection at reasonable fighting range, what is the most economical thickness of armor to adopt? Very many considerations are involved in the answer to this question, such as the position and thickness of horizontal armor; but, considering the enormous sacrifice in weight now made to carry thick armor protection, it is a matter that before long may undergo bold and radical revision.

We now come to the third possibility of saving weight, and that is, reduction in speed. Probably there was no point among the improvements introduced into the "Dreadnought" that was more violently attacked than the increase in speed from 19 to 21 knots, and the attempts made to prove that such an increase was of no value were legion. It is probable that this increase will in time be looked upon as one of the most valuable features of this design. It has been impossible for anyone to argue that, from a strategical point of view, such an increase in speed was not of value, but from a tactical point of view this increase was bitterly attacked. This attack arose from not taking a sufficiently broad view of the possibilities of the future.

The speed of a ship when she is built remains practically constant all her life. Judging from past experience, it is improbable that the designed speed of a ship will ever be subsequently increased. Fifteen years ahead is a long time to look forward to; but the careful student of naval progress is forced to take into account the possibilities of all naval weapons. The improvements in the torpedo must in time introduce a class of tactics more analogous to single ship than fleet actions. It is in such a class of tactics that speed will become a valuable factor, and it is highly probable that the speed of battleships will increase up to that of the cruisers.

It is therefore probable that to get the maximum efficiency out of the gun, and yet not to decrease the numbers mounted in a ship, increase in tonnage and reduction of belt armor of battleships will be features in future construction, and that for other reasons the value of speed will be enhanced.

It does not seem possible that the size of gun will be limited unless all nations agree to do so, and such an agreement is highly improbable. It would be a foolish policy on the part of any nation to install smaller guns than those carried in the ships of rival powers. Again, it would be almost as unwise to provide guns of less damaging power than modern design permits. The number of guns carried in a ship cannot well be reduced below that of the "Dreadnought," otherwise the difficulty of hitting at long range with such an armament will be considerably increased.

To sum up, all the considerations of offense and defense point to increase in size of battleships as modern gun construction advances. But, since the modern battleship no longer holds the supreme position which, in the old days, made the battleship the sole ultimate arbiter of sea power, it is improbable that, as the torpedo improves, battleships, unable to defend themselves against any form of torpedo craft, will be built merely to fight battleships. The functions of the large cruiser will, therefore, be assumed by the battleship, high speed will become more and more necessary, and armor protection will be less accentuated than at present. The link between the ocean-going destroyer and the battleship will become closer, and we may reasonably expect that the huge monsters of the future will always be accompanied by torpedo craft of high sea-going speed as defensive and offensive satellites.

The battleship as now known will probably develop from a single ship into a battle unit, consisting of a large armored cruiser with attendant torpedo craft. Line of battle, as we now know it, will be radically modified, and the fleet action of the future will, in course of time, develop into an aggregation of duels between opposing battle units. The tactics of such units open up a vista of most exhilarating speculation, and will afford to the naval officer of the future a scope for his tactical skill never dreamed of by us.

THEORIES OF IMPACT.

IN a recent number of Habilitationsschrift, C. Ramsauer reviews the elastic and mechanical theories of impact. He states that previous experimental work shows that the course of an impact is now exactly that required by the elastic solid theory. His work deals with the determination of impact velocity and duration of impact, employing a new optical method which allows the course of the impact to be followed independently of all theory. The impinging bodies used were of cylindrical form, and the impact at one end was communicated by means of a lever to a movable mirror at the other end, thus causing the deflection of a spot of light on a rotating drum. The paper is divided into two parts, in each of which one of the theories is tested in the light of experiment. The fundamental condition of the elastic theory, that the impact pressure instantaneously becomes uniform over the section, can be fully realized in practice by the use of spirals and of rubber cylinders with ivory ends. Cylinders of this kind, of the same section and material, fulfill all the demands of the elastic theory as regards the course of the impact, duration of impact and final velocity. Peculiarities noted during impact are due to the dependence of wave velocity on the amplitude of compression, on imperfect elasticity and on elastic after-effect. For small compressions, the wave velocity in rubber reaches a limiting value which lies far above that found by statical methods; from this value the modulus of elasticity can be calculated free from the disturbance due to elastic after-effect. An ideal mechanical impact may be produced by the use of spring heads on solid steel cylinders. This ideal case, besides conforming to the law of conservation of energy, must also be such that the time of impact of equally long cylinders varies as the square root of the length or mass; the time of impact must also be independent of the velocity. The course of the mechanical impact is fundamentally of an elastic nature. If the ratio of the elastic modulus of the rigid portion to the modulus of the head falls from infinity to smaller values, the properties of the impact lie between the two theories; this is the case with the impact of two solid cylinders, which proceeds as though the transference of energy took place by means of a more easily compressible intervening layer.

ARTIFICIAL FABRICS.

THE term "artificial fabrics" is here used to denote, not fabrics woven of artificial fibers, but fabrics produced directly, without weaving, from various solutions of cellulose. Several processes for the production of artificial fabrics have already been patented. The processes form two classes. In one class, the solution or paste of cellulose is divided mechanically into filaments, which, at the moment of solidification, or immediately thereafter, are so assembled as to form an interlacing network of various types. To this class belong the processes of Millar, Drouinat and Chaplet. A better method, however, consists in subjecting the solution of cellulose to a sort of fibrous crystallization, which is brought about either by the action of a coagulating substance upon the moving cellulose solution, or by the influence of the carbon dioxide of the air. To this class belong the processes of Cross, Bevan, and Beltzer. In the methods of the second class the fibers are not arranged in a geometrical pattern, but form a sort of felt in which they cross in every direction.

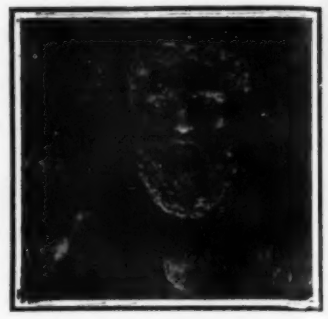
None of these processes, however, has yet been carried out in practice. Still they should not be dismissed as useless. The manufacture of artificial silk was first suggested in the middle of the eighteenth century by Réaumur, yet this manufacture did not assume practical form until 1889, and several years were then consumed in overcoming difficulties of all sorts. It is probable that the manufacture of artificial fabrics, which, by the way, was also suggested by Réaumur, will undergo a similar evolution, and that the present period of experiment will soon be followed by one of industrial development.—Cosmos.

The concept of the ether, according to N. Campbell in the Philosophical Magazine, was developed in order to provide a vehicle for the adulatory energy of light, and is now regarded as the vehicle of all forms of electromagnetic energy. It would, therefore, appear natural to identify points in the ether by the amounts of energy located in them. But consider the case of two or more electrically charged bodies moving with different uniform velocities relatively to the observer. The velocity of the ether relatively to the observer would then be different according as one or other of the charged bodies was considered, and would be, in each case, the same as the velocity of the corresponding charged body relative to the observer. This leads directly to the principle of relativity, which has been proved to form an adequate basis for electromagnetic theory. If it be not permitted so to identify a point in the ether, no other means of identification can be substituted. The first requisite for the application to the ether of the definition of velocity, which is implied in all statements concerning the velocities of material bodies, cannot therefore be fulfilled; until some other definition of velocity is put forward as applicable to the ether, all propositions about velocity of or relative to the ether are meaningless. This objection would be removed if it were possible to define the velocity of a charged body relative to the ether as its "Absolute Velocity." But Absolute Velocity is meaningless unless the fundamentad propositions of dynamics are assumed to be true. It is therefore logically impossible to assert at the same time (1) that axes fixed in the ether are axes of which the Absolute Velocity is nil, and (2) that the Mass of a body increases with its Velocity relative to those axes. It is therefore contended that the concept of the ether should be abandoned, and electromagnetic theory embodied in equations based on the principle of relativity.

Elimination of all level crossings is being gradually effected by the Pennsylvania Railway. Since January 1st, 1900, according to information sent out by the Pennsylvania Company, 673 level crossings have been removed on the lines of this company east of Pittsburg and Erie. This includes only work completed up to September 1st, 1909, and does not include the ten crossings to be eliminated by the projected change of the line through Bristol, Pa., on the New York division. On the lines between New York and Washington, Philadelphia and Pittsburg, 256 public level crossings and 129 private level crossings have been removed in the past ten years, leaving only 774 public crossings, scattered over 574 miles of road. On the division between Philadelphia and Washington alone 106 level crossings have been eliminated, between Jersey City and Philadelphia seventy-eight crossings have been removed, and on the Pittsburg division forty-six crossings have been taken out.

ARCHÆOLOGY IN NORTH AFRICA.

BY THE PARIS CORRESPONDENT OF THE SCIENTIFIC AMERICAN.



THE North African region lying in Algeria and Tunisia affords an almost unlimited field for archæological research, and on some of the sites of the ancient cities this is being actively carried on at present. On the site of Carthage alone there are thousands of tombs which, after remaining buried at depths of twenty or thirty feet underground for two thousand years, are now yielding sarcophagi and funerary objects which throw light upon a hitherto unknown civilization. An immense number of objects is now collected in the museum from the excavation made by the Rev. P. Delattre, one of the leading French archæologists, who has been the chief moving spirit in this great enterprise. The objects of the Punic period or the epoch before the Roman domination are, of course, the most valuable, but the specimens relating to Roman and Christian archæology are also of much interest. Most of the ruins of temples, basilicas, and like structures on the site of Carthage relate to this latter period.

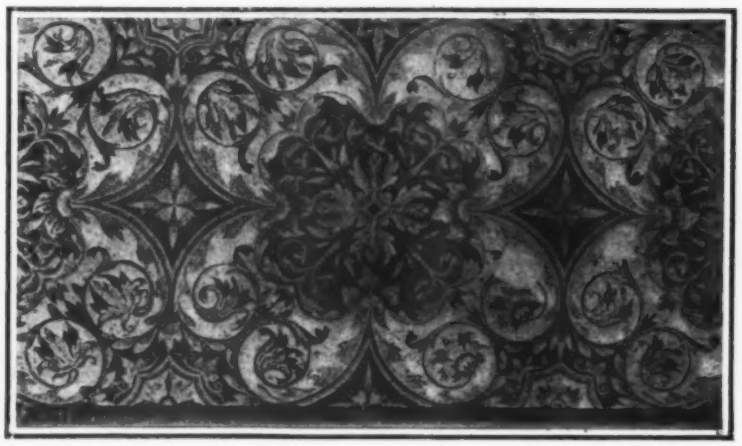
Of the more ancient epoch is the great necropolis of the priests and priestesses of Carthage, and the exploration of the tombs has been carried on within a recent period owing to a subsidy furnished by the Paris Academy. We are able to mention some of the leading features of this work from information which has been kindly furnished us by Rev. P. Delattre. The tombs lie very deep underground, and are reached by a vertical shaft, as is usual in the case of the Punic tombs. The shafts were sunk through the loose ground until they reached solid rock, in order to cut the funerary chamber in this material. In these chambers there are usually found sarcophagi of limestone which contain calcined and broken bones, together with coins and amulets, or in other cases with funerary objects such as vases, phials and mirrors. Sometimes the burial chamber lies as deep as 50 feet below the ground, and in one case, which we may cite as an example, the entry of the chamber leading from the vertical shaft is three feet high and but two feet wide. At six feet above the entry there was a still larger chamber, with two burial pits, and this in turn communicated by a break in the wall with a third chamber, which contained three burial places. The first-mentioned chamber measures seven feet in length, and but four feet wide and about the same in height, and it is difficult to see how the Carthaginians could let down such a large sarcophagus to this depth and then store it in such a small space. Beside the sarcophagus were placed a funerary vase and two cups (paters), and also a lamp of Greek form, with five Punic coins representing Persephone, and also the horse's head, which is typical of Carthage. In another burial chamber was a sarcophagus bearing the inscription, "Tomb of Gratmelquat, priestess of the goddess," referring no doubt to the goddess Tanit, as a statuette of this divinity was in fact found among the funerary objects, as also nine small vases with handles, five black vases, ten two-handled lamps of the Punic type, and seven of Greek form, also eighteen ointment boxes of terra cotta, fifty bronze coins, a small mirror, several pieces in ivory, including a distaff, and other objects which will give an idea of the great variety of specimens found in these tombs. Among other specimens from the tombs is a Carthaginian seal representing a warrior in the act of combat. Gold objects are often found in these tombs, such as a gold ring with the sign of Tanit, gold appliqué ornaments of star shape, ear-rings of different forms, seal rings bearing sacred symbols or portraits of the wearer, and the like.

The sarcophagi which have been taken from the various tombs of Carthage are now preserved in the museum, and there are already a great number in the collection. Among these the most noteworthy are the sarcophagi in white marble, one of which we represent in the illustration. The main body of the sarcophagus was painted with ornamental bordering and various designs, while the stone cover bears a life-size figure in relief. Traces of painting can also be seen upon the sculptured figures and especially in the eyes, which thus have a lifelike appearance. The present sarcophagus bears a figure of a male personage in high relief, having the face bearded, and he is clothed in what appears to be a ceremonial costume. From the upraised position of the right hand, and also from the sacred vessel which he bears in the left hand, as well as from the general appearance of the figure, the person is no doubt a member of the priesthood. The sarcophagus dates from the Punic or pre-Roman period of Carthage, and various remains were found within it, such as a gold ring with a massive seal. The seal bears the image of a head in profile, which appears to be the likeness of the same person who is sculptured on the cover. There were also found a round box containing twenty-four Punic coins, a stone amulet which appears to have been worn upon the breast, and also three gold rings. Not long since the present sarcophagus as well as one which is similar to it and bears a sculptured female figure were transferred to the Louvre museum, where they are to remain definitely.

Excavation work has been carried out actively within the last few years on the site of Timgad, and a great part of the ruins of the ancient Roman city of Thamugadi is now uncovered. The appearance of the ruins, which cover a vast area, justifies the comparison which is sometimes made with Pompeii, this being due to the fact that the remains of houses, temples and other buildings are found in a comparatively good state of preservation, as will be noted from some of the most recent views which we present here. One of these represents the atrium of a Roman dwelling, and three of the columns, as well as part of the stone paving, are well preserved. In the rear will be noticed a large stone basin of semi-circular shape, which has scarcely suffered. Another view represents the remains of a private dwelling, and it is of interest from the large bath-pool which is formed of upright flat stone slabs set on edge and having a range of marble columns

THE MUSEUM AT LAMBESSA.

TIMGAD. ATRIUM OF A ROMAN DWELLING.



A TIMGAD MOSAIC OF PESCINA. LEAF AND FLOWER ORNAMENTATION.

A TIMGAD MOSAIC. CENTRAL MEDALLIONS OF BIRDS.

NEW FINDS IN THE NORTH AFRICAN REGION.

surrounding it. The flooring of the bath-pool was laid in an ornamental mosaic, which we also reproduce. It is one of the many different mosaics which are to be seen at Timgad, and has a handsome decorative design, composed of leaf and flower ornamentation. Still more attractive is the second mosaic, which will be noticed, and it has two central medallions bearing figures of birds.

Marble statues have also been found in various parts of the ruins, and we illustrate one of the most recent, this being the statue of Abundance. It is a handsomely draped figure, and is executed somewhat in the Greek style. The present statue was found in the Forum, and it has been set up on the outside of the museum, together with a number of marble statues, sarcophagi, columns and the like which are assembled from all parts of the site. The museum, the roof of which is set around with capitals of columns, now contains a great number of specimens, and these are continually increasing owing to the constant finds which are being made. Among the principal buildings, the capitol is especially worthy of mention, and two of the gigantic columns are still standing. The great size of these columns will be judged from the appearance of one of the capitals which will be observed here. As there is not enough room in the small quarters of the museum a great number of objects have been collected in what may be called an open-air museum. Prominent among these will be seen the stone flour mills, which, as is usual in the Roman mills, have square openings in the sides for use in inserting the beams so as to drive the mill. Such mills have been found at Pompeii and other places.

An interesting site in the North African region is the Roman camp of Lambessa, which lies in the region of Timgad. Since our previous account, there has been a number of objects brought to light on this spot, although the greater part of the site still lies underground. The camp of Lambessa may be taken as unique of its kind, and nowhere do we find a Roman one of such importance, in spite of the destruction which it underwent through the ravages of time. Should it ever come to be exposed methodically, it will no doubt give the solution of a great number of questions which we cannot answer as yet concerning Roman military work. The camp was a rectangular inclosure and well fortified, containing a gate on each of the four sides. The Pretorian gate was flanked by two semi-circular towers and had a double vaulted passage, somewhat recalling the fortifications of the Middle Ages, but the walls of the camp were not surrounded by a moat. Inside one of the bastions at an angle of the camp, were found stone projectiles about the size of an egg, which served for the catapults and like engines. Near the camp extended the town of Lambessa, which was an outgrowth from the former. Most of it, however, remains to be excavated. One of the most recent finds is the handsome bronze statue of Ganymede, which is executed in the Roman style and represents a child carrying the eagle of Jupiter. Enameled eyes were inserted in the spaces which now appear empty. We also show a number of marble statues found at Lambessa since the excavations were first made. A very handsome mosaic, with a subject representing Bacchus, is also among the noteworthy objects.

FORMATION OF OZONE BY THE ACTION OF ULTRA-VIOLET RAYS.

In the year 1909 Lenard discovered that ultra-violet rays ozonize the surrounding air. The phenomenon can now be very easily observed, for the characteristic odor of ozone is strongly marked in the vicinity of the mercury vapor lamps which are now often used for illumination. A short time ago, Bordier and Nogier attempted to detect, by chemical methods, the ozone produced by ultra-violet rays; but, although they used a very sensitive method, they obtained a negative result. Hence, they announced that no ozone is produced by the ultraviolet rays of the mercury vapor lamp, and explained the observed odor as a purely objective phenomenon.

Van Aubel has recently endeavored to detect the presence of ozone in air traversed by ultra-violet rays, and has obtained decisive positive results. In one of his experiments olive oil, in which ozone is readily soluble, was allowed to remain for about two hours in the outer glass globe of a quartz mercury vapor lamp. There it was exposed to intense ultra-violet radiation. The oil was entirely bleached. A mixture of starch paste and potassium iodide solution turned blue when mixed with this oil, showing that the oil contained ozone in solution. This reaction was not produced by olive oil which had not been exposed to ultra-violet rays.

The same reaction was shown still more strongly by petroleum, under the same conditions. Another striking proof of the formation of ozone is described as follows: A piece of filter paper saturated with potassium iodide and starch was laid in a shallow porcelain dish. Partly covering the strip of paper and about one-twentieth inch above it, was placed a plate of quartz, about 1-6 inch thick. The dish was placed on the bottom of the glass globe of the mercury vapor lamp, so that the filter paper was exposed to the ultra-violet rays. These rays penetrated the quartz plate; but the ozonized air which was contained in the globe could not readily flow under the quartz plate, although it could reach without difficulty the parts of the paper which were not covered by the plate. After the exposure had continued about two minutes, the part of the filter paper which was not covered by the plate assumed a dark blue tint, while the other part of the paper remained nearly white. This result proves that the coloration is produced by the ozone in the air, and not by any direct action of the ultra-violet rays.

CHEMISTRY AND ARCHÆOLOGY.

CHEMISTRY and archæology are two provinces which apparently, it may be said, have no common point of contact; the former does purely practical work with the aid of the crucibles, funnels and retorts of the laboratory, and the latter embraces a field which the historian and the philologist in the ancient languages is accustomed to work with the help of his theories in the quiet of his study. Occasionally, however, the latter is confronted with the fact that it can use also certain of the latest incontrovertible dicta of natural science as a means for deeper recognition. So it happened, says Dr. Rammstedt in a comprehensive report published in a recent number of Die Naturwissenschaftliche Wochenschrift, that the Paris chemist, Prof. Le Chatelier, strove successfully to ascertain the temperature at which Greek pottery was burned, which was approximately 950 degrees Celsius, the same stupendous heat that is used at the present day to burn earthen-ware and products of clay, and that he was the first to be able to prove that in regard to porcelain the old Egyptians were not, as was formerly assumed, dependent on remote China for that product, but themselves manufactured such a ware that, when its chemical composition is considered, was precisely like the ware that is produced still to-day in Sèvres. Very seldom, indeed, will chemistry fail, says Prof. Neumann of Darmstadt, to decide whether or not a work of art, a figure of bronze or a metal vessel, for instance, is genuine, that is, to attribute the work to a correct date, for the chemical composition of the alloys changes very much in the course of time, and the certain partial transformation which such a work suffers under the influence of the air also depends on its constituents. The examination of a lead pipe 2,000 years old that was found on the island of Broni before the entrance to the harbor of Pola has shown, says Fieber, that, like the cement pipes or conduits used in modern canal construction, it was made of two tubes, one drawn through the other, which were soldered together, and thus as one conduit were capable of resisting a great pressure.

Further enlightenment is afforded by the examination, made in conformity to natural science, by Prof. Dragendorf of Frankfurt a. M., of traces of the victuals once used as rations by the soldiers of ancient Rome. The Roman camp near Haltern, in which many persons believe they recognize the fortress-castle Aliso erected by Drusus in the year 11 B. C., was probably a great emporium for all those things which the Roman General Staff had to send to the rear of the Rhine and the Lippe to its soldiers invading Germania. The pottery found there, which was for the conservation of wine, oil and similar beverages and foods, must be attributed, as research has shown, mostly to the South, while the large amphorae, which were used for the transportation of grain, were made already at that time in Castra Vetera, the old Xanten on the Lower Rhine. As the examination of the piles of refuse near the Saalburg has shown, the soldiers' rations consisted not only of bread, for the preparation of which the grain was ground in small hand-mills, but also of fish, snails, mussels and oysters, as well as many kinds of fruit, especially peaches. Of the great earthen vessels used for the transportation of commodities the few specimens extant are marked with many inscriptions regarding their former contents. These marks indicate the strict care with which the Roman General Staff did its official work; and from them may be seen that already at that time an extensive trade in wine was in normal progress along the Rhine to which numerous districts contributed their vintages. Of metal vessels the common man of that day knew very little if anything; he ate from earthen, mostly unglazed, plates and cooked in pots of the same ware. As may be seen, natural science and a chemistry of victuals, which seem to have come 1,900 years too late, are nevertheless able to establish still to-day much that is of luminous interest, and to afford praiseworthy enlightenment in a province of knowledge which the philologist in ancient languages and the historian has hitherto considered as belonging exclusively to himself.

TIMGAD. ARCHITECTURAL ORNAMENTS OF THE CAPITOL.

BRONZE STATUETTE OF GANYMÉDE AT LAMBESSA. A CHILD CARRYING THE EAGLE OF JUPITER.

THE STONE COVER OF A WHITE MARBLE SARCOPHAGUS OF THE PUNIC OR PRE-ROMAN PERIOD OF CARTHAGE. LIFE SIZE.

NEW FINDS IN THE NORTH AFRICAN REGION.

WHERE TO FIND THE STARS.

A LINK BETWEEN THE STAR MAPS AND THE SKY.

BY F. R. RUSSELL.

IT is very difficult to recognize stars by studying the star maps and then seeking in the sky the stars marked on the maps. But if we come to know our way in the heavens, so as to be able to find readily the Celestial Equator, Celestial Poles, Ecliptic and our Zenith, and notice the position of a star relative to these points and lines, it is not at all difficult to refer to the same places on a map and find the name of the star desired and the constellation to which it belongs.

To know our way thus in the heavens we must always remember the exact point on the earth from which we are looking. The earth is divided into 360 degrees north and south, and 360 degrees east and west, and the vault above us is divided into corresponding degrees. The equator divides the earth into two equal parts, and the line due north and south connecting the poles is at right angles with the equator.

As the earth is divided into 360 degrees north and south, the heavens which inclose it are likewise divided into 360 degrees. We can see half that amount, 180 degrees, at one time. The other half envelops the half of the earth below our feet and is, consequently, invisible to us. We see 90 degrees from the horizon on our right-hand to our zenith and 90 degrees from the horizon on our left to our zenith, our zenith being the exact point overhead where we may be standing at any given time.

If we are placed on any spot between pole and equator we see these latter landmarks at different angles in the heavens. At Greenwich, which has the latitude 51½ N., the parallel in the dome above us is 51½ N. at our zenith. We see 90 degrees between the celestial equator and the celestial north pole, and the remaining 90 degrees is made up by the difference between the north pole and our horizon on the one side, and between the equator and our horizon on the other.

The celestial equator, seen from latitude 51½ N., is rather less than half-way up between the southern horizon and the zenith, and the celestial north pole is rather more than half-way up from the northern horizon. That is, we see from our northern horizon to the north pole in the heavens 51½ degrees, from the pole star to our zenith 38½ degrees, making 90 degrees from horizon to zenith on the northern side. On the other hand, if we face south instead of facing north, we see from the southern horizon to the celestial equator 38½ degrees, and from the equator to our zenith 51½ degrees. That is, 90 degrees from the southern horizon to our zenith, and 90 degrees from the northern horizon to our zenith—180 in all.

Only the stars traveling on that portion of the heavens are visible to us from our latitude.

Our horizon line on the south is 38½ S., and our horizon line on the north is 38½ N.

In Oporto, Portugal, latitude 42 N., the horizon lines are 48 N. and 48 S. In Wellington, New Zealand, latitude 42 S., the exact reverse holds good, the South Pole taking the place of North Pole, and the southern horizon that of the northern horizon. In the northern hemisphere the southern horizon is so many degrees below the celestial equator, according to our latitude, and the northern horizon is so many degrees above the celestial equator which is not visible to us from that side.

From atmospheric conditions heavenly bodies look larger, and the space they travel through seems greater, when near the horizon, and a planet or star at 45 degrees above the horizon will look more than half way up to the zenith, which it, in fact, is.

In the heavens degrees count from the equator to the poles as on the earth, the equator being 0 and each pole 90; but instead of calling those degrees parallels of latitude they are called declensions, though they correspond with our terrestrial latitudes. Standing on latitude N. 20 (as in Mexico) the corresponding line overhead is also 20 N., but a heavenly body on that line is said to "have the declension 20. N."

To find our way east and west in the heavens is more difficult than north and south, because the earth's motion has to be taken into account. The earth has many and complicated movements on its journey through space, but the only two that much affect us in watching the stars are the diurnal one as it turns on its axis every 24 hours from west to east, and the annual one as it journeys on its path round the sun every year, also from west to east.

A position on the earth east and west is determined by meridian lines of longitude. Any line drawn straight from pole to pole, cutting the equator at right angles, is a meridian line.

The line through Greenwich is chosen to count from by all English-speaking countries, and is called the First Meridian, the earth being divided into 360 degrees, 180 east, and 180 west.

Most Continental towns count from the meridian of Paris, instead of that of Greenwich. There are also meridian lines in the vault above us, but instead of being called longitudes they are called right ascensions.

A line in the heavens which is directly over a certain place at 12 noon will no longer be over that place at 1 o'clock, because the earth will have shifted itself eastward a twenty-fourth part of its diurnal journey in that time, or 15 degrees. If the sun is over the meridian of Greenwich at 12 o'clock, as the earth revolves eastward at the rate of 15 degrees an hour, the sun will be directly over the meridian of all places 15 degrees west of Greenwich an hour afterward, when it is one hour after noon at Greenwich.

When the sun is directly over the meridian of any place it is mid-day or noon to that place. As the sun rises toward the east and sets toward the west, when it crosses the line due north and south, or the meridian, it has made half its journey, and is, consequently, at its highest point in the heavens. It is the same with the stars.

As the earth revolves on its axis every 24 hours the whole dome of stars appear to turn round over our heads in that time. That is, if we were standing on one of the poles, with the corresponding pole in the heavens directly in our zenith, we would see all the stars make a circuit round the point overhead, as though we were standing still in the center beneath a revolving dome. The stars near the pole make a very small circuit, while those farther off move in a larger circle, the circles growing larger and larger until they reach the horizon, when, being on the celestial equator, they circle the whole round of the heavens.

On the contrary, if we were standing on the equator we should see all the stars rise and set, some traveling right overhead, rising due east and setting due west, others whose circuits are smaller ones nearer to the poles rise to the north or south of east and set to the north or south of west, their path making an arc in the sky, but never reaching the zenith.

At 20 N. lat. (in Mexico, for instance) almost all the stars disappear beneath the horizon, only a very few whose declensions are very near the North Pole being visible in their entire circuit.

This diurnal motion of the stars round the pole makes it easy to find the pole in the sky. In the northern hemisphere there is a star, the Pole Star, within 2 degrees of the celestial north pole, and any night the surrounding constellations can be seen circling round this point.

As the journey round the pole takes 24 hours, the difference in their position every 3 hours is very apparent, being an eighth of the whole distance. If we look at the Great Bear any night at 9 o'clock, and again at midnight, it is easy to recognize this motion of the stars. The stars nearer the pole have a small circuit, and those beyond the Great Bear have a larger and larger one, according to their distance, and, consequently, sooner or later, dip below the horizon. In the southern heavens there is no star like the Pole Star in the north, but the South Pole is easily recognized as the pivot round which the constellations turn. The Southern Cross, with its pointers, the two bright stars in the "Centaur" and "Triangulum Australis," nearer still to the pivot of the southern heavens, can be watched circling round the southern pole night by night, at all seasons, in the same way as the Great Bear circles round the North Pole.

The apparent path of the sun is called the "Ecliptic." There are certain constellations like a broad band, through which this ecliptic runs, and which make an easy mark in the heavens and help us much in finding our way in the sky. These constellations are called the zodiacal constellations, and are each marked by a sign of the zodiac peculiar to itself. They are visible at night only at certain seasons of the year, depending on the position of the earth as it travels round the sun among the stars.

The stars whose circuits are small and near the poles are visible every night of the year in their respective hemispheres, but those that circle round the equatorial regions are visible at certain seasons only; at least, early in the night. This is easily understood if we take a ball of wool and a lamp as an example. As we move the ball round the lamp in the center of the room, the ball represents the earth, the lamp the sun, and the walls of the room the star-sphere. The path in which the ball is moved represents our orbit or path round the sun, and it will be seen that as it travels round the lamp (or sun) is sometimes between us and one side of the room and sometimes between us and the other side. When the sun is between us and one side of the star-sphere, that side of the star-sphere is concealed from our view by reason of the light of the sun, while the other side of the star-sphere is visible to that half of the earth which is turned from the sun and to which it is night. Each half of the earth is alternately every 12 hours in light facing the sun with the invisible heavens beyond, or in shade facing the visible heavens without the sun.

As we travel round, the sun appears in a line with every constellation on the ecliptic in succession. The lamp is, as it were, projected against, first one object, then another, on the walls in a line behind it. Our journey round the sun takes a year, and twelve constellations have been noted at nearly equal distances through which the sun appears to travel, and are called zodiacal constellations. When the sun is projected against, or in a direct line with, one of these it is said to be "in" such-and-such a constellation. At that time this constellation is invisible at night, because it has set with the sun, having risen with the sun in the morning and traveled with the sun across the sky during the day. All the stars in the equatorial regions have their seasons in the same way.

We see 180 degrees or half the heavens at a time, thus six of these zodiacal constellations are visible at once. The earth moves round the sun from west to east, taking 12 months for the journey, and being in one of these constellations each month. Consequently if one constellation has set with the sun in the west the next eastward to it will be the distance of a twelfth part of the ecliptic above the western horizon, and in the next month will be setting with the sun in its turn.

As the earth in a year completes its journey through the dome of stars, traveling from west to east, we are always moving on this journey as well as turning on our axis.

If we only turned on our axis we would find any given star in the same position at the same hour night after night. As it is, the earth, having moved eastward on its annual journey to the amount of one degree, any given star appears farther west at the same hour, each night, to that amount. One degree represents four minutes in time, so that a star being one degree westward each night is seen four minutes earlier above the eastern horizon, or, to express it otherwise, rises four minutes earlier every night—roughly speaking, half an hour a week and two hours a month. Thus, if we look for a certain star at a certain spot in the heavens at 10 o'clock to-night, we must look for the same star at the same spot at 9 o'clock a month hence. Or, otherwise, if we seek for a star on our meridian at 8 o'clock to-night, we must look for the same star 30 degrees west of the meridian at 8 o'clock a month hence.

The position east and west of each star in the heavens is mapped out in the same way as its position north and south. The 360 degrees north and south are, as we know, counted from the equator to the poles and are called "Declensions."

The degrees east and west are counted from the point in the heavens where the sun is found at the March Equinox, that is, the first point in "Aries," one of the zodiacal constellations, and are called "right ascensions." They are counted either in degrees 360 or in hours 24, each hour representing 15 degrees. Wherever we may be on the earth we see the stars cross our meridian at 12 o'clock; this tells us of position in regard to the sun, but it does not tell the earth's real (and the sun's apparent) place among the stars at any given date. This is calculated by "right ascensions." Each star has its position in regard to the 1st point in Aries mapped out so many degrees (or hours) East. When the sun appears in a line with such-and-such a star of such-and-such "right ascension" we know our place in the heavens at the time, and how far we have traveled on our annual journey from Aries back to Aries again. Each star has its "right ascension" and this right ascension comes to our meridian once in every 24 hours as we turn on our axis. The "right ascension" and declension of every star is given in most star atlases and almanacs, and the hour of each star's passing

meridian of Greenwich at different seasons is generally added.

By knowing the part of the ecliptic where the sun is at a given date and the right ascension of the constellation with which it is on a line, it is easy to compare the right ascension of any given star and to see if it has passed the meridian before the sun, when we cannot look for it early in the night, or whether it will pass the meridian soon after the sun, when we may look for it to be visible in the heavens as soon as the sun has set.

Seeing Aries just above the horizon, setting in the west, we may look for Libra soon to rise in the east, as, if the sun is now in Aries, it will be in Libra six months hence, and Libra will then be setting at sunset, and has, consequently, half the heavens to traverse in the six months. Between Aries and Libra come Taurus, Gemini, Cancer, Leo, and Virgo, visible in succession across the ecliptic.

If we refer to our almanac and find the sign in which the sun is at the date we seek we may look for the zodiacal constellations of the six months following, in the sky after sunset, the remaining six constellations being below the horizon.

The signs of the Zodiac are written as follows:

♈ (Aries), ♉ (Taurus), ♊ (Gemini), ♋ (Cancer) ♌ (Leo), ♍ (Virgo), ♎ (Libra), ♏ (Scorpio), ♐ (Sagittarius), ♑ (Capricornus), ♒ (Aquaris), ♓ (Pisces).

The first six are north, and the remaining six south, of the equator.

Most of the zodiacal constellations are conspicuous by one (or more) bright star.

Aries possesses one star of the 2nd and two of the 3rd and 4th magnitude, making a curved line.

Taurus is easily recognized by the brilliant 1st magnitude star Aldebaran, which is accompanied by a V-shaped cluster of bright stars forming a figure not unlike a bull's head, Aldebaran being at one point. The constellation of the Pleiades, a cluster of six bright stars, is in the bull's shoulder.

The Gemini consist of two brilliant 2nd magnitude stars (sometimes counted as 1st magnitude) of nearly the same size, and of many smaller stars forming the continuation of the Twins as far south as Orion.

Cancer is a miserable little group hardly discernible, forming a sort of square, and is best found by being on the direct path of the sun, between Gemini and Leo. There is no star above the 4th magnitude in it, but this constellation is often quoted, as the sun is in the sign of Cancer when it reaches its highest point north 23½ degrees. Cancer contains a remarkable nebula, not visible to the naked eye.

Leo is shaped like a sickle, with a beautiful 1st magnitude star, Regulus, in the handle.

Virgo stretches a long way across the heavens, its most southerly point ending in Spica, a 1st magnitude star 10 degrees south of the equator representing the ear of corn which the Virgin holds, the sun being in Virgo during the harvest month in the north.

Libra, the balance, is entered by the sun at the September Equinox. It is not very unlike the Twins, having two stars in a straight line, of an equal size, but the stars are not so large as Castor and Pollux, and are not so close together. This constellation is quite eclipsed by the one following it.

Scorpio, the scorpion, which not only boasts of Antares, an exquisite reddish star, as its "heart," but has two bright 2nd magnitude stars at its southern extremity, and a cluster of bright 3rd magnitude stars at the northern, close to Libra.

Sagittarius, the Archer, comes next, also south of the equator, with four bright stars (of 2nd and 3rd magnitude) making a kind of square, narrowing toward the north and with four brightish smaller stars farther north still.

Capricornus, the Goat, contains no star beyond the 3rd magnitude, but a pair of two which comes close together has somewhat the resemblance of horns.

Aquarius, the Water-carrier, is also far from striking, but can be found with no great difficulty by a cluster in it something like an incomplete W.

Pisces, the twelfth zodiacal constellation, is made up of a group shaped like a palm leaf, also a number of tiny lines of small stars seen only well on clear nights, continued as far south as Fomalhaut, in Pisces Australis, a brilliant 1st magnitude star shining as far as 30 S.

When we are acquainted with the zodiacal constellations and with the circumpolar ones it is not difficult to master the remaining principal groups in the heavens.

The chief constellations round the North Pole are: First the Great Bear, with its seven bright stars, two of which, called the Pointers, point direct to the pole, the Pole Star itself being in the tail of the Little Bear. At the opposite side of the Polar Star in Cassiopeia, forming a clear W, the W representing the chair on which she is sitting. The Dragon joins the two Bears. A little farther south the brilliant stars Vega in Lyra, and Capella in Auriga, are nearly equi-distant from the pole, and are seen all the year round from Greenwich. If one is high toward the zenith the other will be low on the horizon, according to the season and hour of night.

In the southern hemisphere there is no star exactly at the pole, but the Southern Cross circles round it, containing two stars of the 1st magnitude and one of the 2nd, while the two brilliant pointers, Alpha and Beta, of the Centaur, make it easy to find. At one side of the Cross, even nearer the South Pole, is the Southern Triangle (Triangulum Australis), consisting of three stars equal in size, easily recognized. At the other side is the magnificent constellation of the Ship, Argo Navis, containing Canopus, one of the brightest stars in the heavens, as well as Eta Argus, which varies in brilliancy, reaching the 1st magnitude at its brightest.

Any constellation in the same position east and west, with one of the familiar zodiacal ones (having, that is, the same right ascension), will be visible when that zodiacal constellation is up in the heavens.

For instance, when the Gemini and Taurus are to be seen traveling across the sky, we may look for Orion (the Hunter) to the south with his companions, Canis Major and Canis Minor—the Greater and Lesser Dog.

This splendid group contains four 1st magnitude stars, Sirius, in Canis Major, being the brightest in the entire heavens, then come Procyon in Canis Minor, and Rigel and Betelgeuse in Orion. This group being south of the equator, the greater part is visible for a longer time in the southern hemisphere than in the northern.

Again, when Sagittarius, the Archer, has risen above the horizon we may look for Aquila, the Eagle, containing Altair, a star of 1st magnitude, and close to it the dear little cluster, the Dolphin. Also three 4th magnitude stars in a tiny line between Aquila, the Eagle, and Cygnus, the Swan, which represents Sagitta, the Arrow, presumably shot by the Archer toward these birds.

Lyra is close to Cygnus, and somewhat southwest of these constellations is the lovely little constellation of Corona, like a diadem in shape, formed by six stars, one very bright.

The Milky Way, a belt of innumerable tiny stars, appearing like a luminous track across the heavens, makes another clear mark for us to follow in the sky. In the southern heavens there are gaps of darkness in this luminous track known as the "Coal Sacks," and the Southern Cross is close to one of these gaps.

There are only about twenty 1st magnitude stars.

1. Achernar in Eridanus.
2. Aldebaran in Taurus.
3. Antares in Scorpio.
4. Altair in Aquila.
5. Arcturus in Bootes.
6. Alpha Centauri.
7. Alpha Crucis.
8. Beta Crucis.
9. Beta Centauri.
10. Betelgeuse in Orion.
11. Canopus in Argo.
12. Capella in Auriga.
13. Eta (variable) in Argo.
14. Fomalhaut in Pisces Australis.
15. Procyon in Canis Minor.
16. Regulus in Leo.
17. Rigel in Orion.
18. Sirius in Canis Major.
19. Spica in Virgo.
20. Vega in Lyra.

When we have mastered the chief constellations and are acquainted with all the 1st magnitude stars, if we see a bright star where no star should be we may conclude that it is a planet.

Most almanacs give the dates when planets are visible and in which constellation—always a zodiacal one—they are to be found. There are eight planets, not counting the small ones, between Mars and Jupiter. These eight are in the following order as regards the sun—each has its accompanying "character," which is marked in the almanacs:

Mercury, ☿; Venus, ♀; the Earth, ♁; Mars, ♂; Jupiter, ♃; Saturn, ♄; Uranus, ♅; and Neptune, ♆.

Of these Uranus and Neptune are not visible to the naked eye, so, with the earth also deducted, there are only five planets which we can see.

Two of these, Mercury and Venus, are only visible as morning and evening stars, and Mercury, being so near the sun, is rarely to be seen at all.

When we see a planet rise in the east, travel across the sky at night, and set in the west, keeping the motion of the stars that we are acquainted with on the zodiacal line, even without the help of the almanac, we know that it must be either Jupiter, Mars, or Saturn, and we can make a good guess by its appearance which of the three it is. Jupiter is much the brightest, Mars shines with a red glow, and Saturn has a light so much duller than the other planets that (together with its peculiar motion among the stars) it was thought by the ancients to have an inauspicious influence.

The planets travel slowly, but quite perceptibly, among the constellations, changing their places relative to the fixed stars. These fixed stars, as we have seen, each appears to travel across the sky night after night, but keep their relative positions in regard to each other so as to form recognizable constellations. Whereas the planets are to be seen sometimes in one constellation and sometimes in another. Thence they originally received their name of "Planets," "Wanderers."

Besides the sun, moon, planets, and fixed stars, there are comets and meteorites which visit our field of view, but their movements are, for the most part, beyond an amateur's calculation.

There are also star clusters and nebulæ, but these are hardly visible to the naked eye. Stars are of various colors—white, green, orange, and red.

These, when they are "doubled," have often blue, green, or violet companions. Double stars are not seen by the naked eye.

The principal 1st magnitude stars are white; among these come Sirius, Vega, Rigel, Altair, Regulus, and Fomalhaut. Our sun is a yellow star; also Capella, Arcturus, Aldebaran, and Pollux. The principal orange star is Antares in Scorpio; also Mira, the variable star in Cetus. There are no red stars of great importance. The white ones are in a state of glowing heat. The yellow are intensely hot, but less so than the white; orange stars are cooling down, and the red are cooler still.

Some stars vary in brilliancy with different periods for their terms of change. The most renowned variable stars are: Algol in Perseus, having a period of 2 days, 20 hours, and 48 minutes. Mira in Cetus, called "Marvellous" on account of its change from brilliant orange-red to insignificance. At its brightest it is just visible to the naked eye. Its period is 1 month. Betelgeuse in Orion varies from the 1st to the 6th magnitude, and Eta Argus varies from the 1st to the 7th. At its brightest it rivals Sirius, which is the brightest in the heavens.

Several stars are called double stars, that is, have a companion revolving with them. Sirius has one so much smaller than himself that it may only be a satellite. Among other remarkable doubled stars are: A pair in Lyro, yellow and green; a pair in Orion, orange and blue; Rigel and companion, white and blue; a pair in Virgo, rose colored.

The earth, with the rest of the solar system, sun, moon, and planets, is hourly traveling at an incredible speed toward a remote point, at one time believed to be a small star in Hercules, but astronomers are discovering daily new revelations, and our destination is, I believe, not finally fixed. The solar system means our sun and all his belongings, whereas the expression "sidereal heavens" means the sphere of stars as distinct from our solar system.

Our sun, of course, is only one of the stars which adorn the wonderful Star Universe, of whose marvels new discoveries are hourly coming to light. But the heavens, as we see them with the naked eye, remain the same from generation to generation.—Knowledge and Scientific News.

A writer in International and Marine Engineering states that in a new ship it was found that the thrust was running hot, and a considerable amount of attention had to be paid to it. It was attributed in the first instance to the way in which the cargo was distributed throughout the ship, as it was thought that the load had disturbed the line of shafting running from the engine to the propeller. In order to minimize the difficulty water was run on to the thrust shoes in order to keep them as cool as possible, and in addition the trough under the shaft was kept full of oil, so that the revolving collars dipped into the oil, and so lubricated themselves. In spite of all this, however, the thrust still ran hot, and this presented a problem which was not satisfactorily solved until after twelve months' continuous trial. It was at last decided, however, to cut on each of the eight collars four oilways on the headway side. These oilways did not run right down to the shaft, but very near to it, so that they formed four radial pockets for oil. When the collar came round each time with the shaft these pockets dipped into the oil and water in the trough and carried some of the mixture round with them. This plan enabled the bearing surface of the thrust to be lubricated practically throughout its whole width, instead of, as before, at the circumference and such points as those to which the oil penetrated. This increased lubrication device effectively stopped the heating up of the thrust altogether.

According to Electrical Engineering three Danish engineers recently made public in Copenhagen a new invention by which any telephone subscriber can, in the absence of the called subscriber, send a telegraphic communication. The apparatus at the transmitting end comprises a keyboard like that of an ordinary typewriter, and the message is received at the other end on a tape printed in ordinary characters.

TABLE OF AEROPLANES AT OLYMPIA.*

SOME OBSERVATIONS ON THE THEORIES OF FLIGHT.

WE publish this week a table of the aeroplanes at Olympia, wherein will be found the leading particulars relating to each machine. These details we were courteously permitted to obtain by direct measurement in cases where the dimensions required were not known by the representative in charge, but in many instances the designers themselves have supplied the particulars. The data that this table contains are particularly interesting at this early stage of the industry, and we have endeavored to make the table as complete as possible in respect to those leading dimensions that may be considered as salient in any machine.

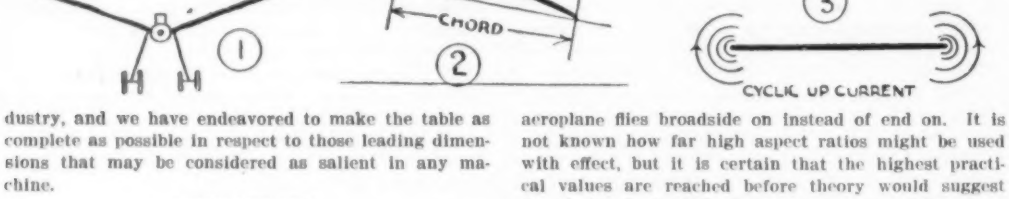
SUPPORTING AREA.

The first column gives the area of the main planes, which in every case carry the greater part, if not the whole of the weight. Most machines nowadays have a tail, which commonly supports itself in the air, and a proportionate amount of the outrigger on which it is carried. Without knowing the exact basis of the design, however, it is not possible to arrive at values in connection with the action of the tail, and in any case the intensity of its loading is far less than the value that obtains in connection with the main planes. The areas given are the result of multiplying the span by the chord, with allowances for irregularities in contour.

In the second column of the table will be found the areas of the elevators, while the third column contains similar particulars relating to the rudder.

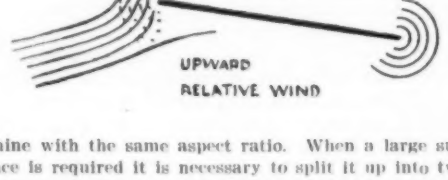
SPAN AND CHORD.

The next series of columns relate to the principal linear dimensions. The first of these columns relates to the span (1) or width of the machine regarded from in front. The chord (2) is the fore and aft dimension of the main planes, measured in a straight line between the leading edge and the trailing edge. The fact that this dimension is actually measured along the chord of the arc formed by the cambered section of the plane is sufficient evidence of the appropriateness of the term as a description of that particular dimension, but it is not without interest to remark that it was, comparatively speaking, a long time before we had the "happy thought" that brought this word into use. Up to that time the dimension had always been referred to as the fore and aft dimension of the main plane; a clumsy definition that it was obviously essential to simplify for everyday use. It has been suggested that the dimension should be called "fore-aft," but although the derivation of such a term is obvious, we do not see that it has any advantages over the term that we now use.



ASPECT RATIO.

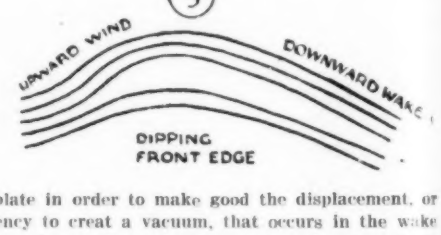
Dividing the span by the chord gives the aspect ratio of the planes, and the higher the aspect ratio the greater should be their lifting efficiency. The reason why aspect ratio is important is because the air that spews out laterally over the side edges of the planes represents loss, consequently the length of the side edges should be kept short in proportion to the length of the front and rear edges; in other words, the span should be relatively large in proportion to the chord, i. e., the aspect ratio should be large. It is on account of the value of aspect ratio that an aeroplane flies broadside on instead of end on. It is not known how far high aspect ratios might be used with effect, but it is certain that the highest practical values are reached before theory would suggest the limit. It is difficult to construct machines having very high aspect ratios so that they shall be sufficiently strong and light for aviation purposes. It is also due to the value of high aspect ratios that the biplane and the triplane exist as types. It would be just as easy—in fact, easier—to make a monoplane with as large a surface as any biplane ever built, but it would be well-nigh impossible to make such a machine with the same aspect ratio. When a large surface is required it is necessary to split it up into two or more sections—that is to say, to build a biplane or a triplane. With a triplane it is even easier to obtain a high aspect ratio than with a biplane, and it will be observed on reference to our table that the Roe triplane has the highest aspect ratio of any machine, with the exception of the Short biplane owned by Moore-Brabazon, which is a very much larger machine altogether. The least aspect ratio is to be found in the little monoplane of the Santos-Dumont type.

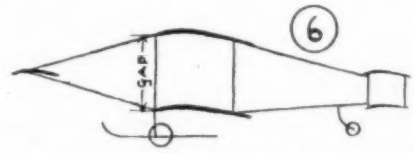


CAMBER AND ITS PURPOSE.

The fourth column in the table devoted to lengths is headed "Camber" (2) and the term has been used to define the dimension that in correct terminology should be expressed as the "maximum versine of the curvature of the fore and aft section of the plane." In other words, it is the maximum height above the chord of some point upon the lower surface of the plane. The term "versine" not being generally in use outside geometry and mathematics, whereas the term camber is an ordinary dictionary word, it is obviously more convenient to use camber in this connection. The values of the camber on different machines are, as will be observed, rather varied. The least is the amount on the Avroplane, but since the camber should always be considered in relationship to the chord, which is a small dimension on this machine, the amount of the camber does not represent such a flat plane in this case as on the Zodiac biplane, where the degree of flatness is quite remarkable. The camber coefficients in the next column, which show the camber as a percentage of the chord, show the relative flatness of the planes at a glance.

Aeroplanes are cambered because the lifting efficiency of the cambered plane has been found to be very much greater than the lifting efficiency of a perfectly flat plane inclined to the line of flight, and the reason that it should be so is not difficult to appreciate, although it is often misunderstood. One inseparable consideration that must be taken into account in connection with the cambered plane is the theory of the dipping front edge. An aeroplane does not fly with its leading edge tangential to the line of flight, as some people suppose, but has its leading edge dipping down so as to be tangential to a relative upward wind. This relative upward wind actually exists as the result of what is known as the "cyclic up-current" in the vicinity of the leading edge. If a flat plane be dropped face downward through the air, the air will be caused to spew out around the edges of the plate (3). As the plate falls, the air in the vicinity of the edges will flow upward from beneath the plate in order to make good the displacement, or tendency to creat a vacuum, that occurs in the wake of the plane. There is thus a transference of air from beneath the plate to the space above the plate always going on while the plate is in motion through the air, and it is obvious that this "cyclic up-current" exists whether the plate be falling to earth or traversing the air in any other direction. It exists in the inclined aeroplane, and being compounded with the horizontal motion of the plane itself, creates a relative upward wind in the immediate vicinity of the leading edge (4). If, therefore, it is desired that the aeroplane shall receive the air without shock, then it is obvious that the aeroplane must fly with a dipping front edge (5). In this position the aeroplane meets the relative wind tangentially, and as it is driven onward through the air its camber converts the upward wind into a downward stream in the wake. In effecting this reversal of direction the aeroplane has exerted a downward force that, by Newton's law, exerts an equal and opposite upward direction. This is how the aeroplane develops its lift or capacity for supporting itself in flight.





THE GAP AND WHY IT IS EQUAL TO THE CHORD.

The sixth column in the table of lengths contains dimensions relating to the gap of multiplanes (6). The gap is the vertical height between one plane and that which is immediately above it. It will be observed that the gap is in most cases approximately equal to the chord. It is not really known quite how

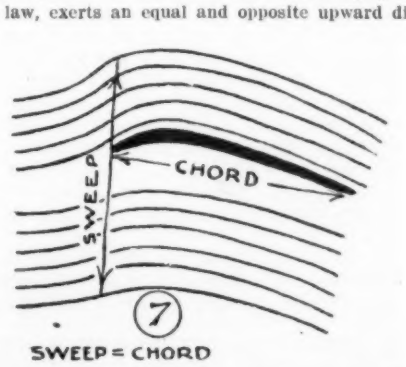


TABLE OF AEROPLANES AT OLYMPIA, 1910.

Name.	Type.	Areas. Main Planes	Elevator.	Rudder	Lengths. Span.	Chord	Aspect Ratio.	Camber.	Camber Coeff.	Gap.	Skid Track.	Length O.A.	Angles. Incidence.	Dihedral.	Screw. Diameter	Pitch.	Pitch Coeff.	In Flight. Weight	Loading	Speed	
		sq. ft.	sq. ft.	sq. ft.	ft. in	ft. in		ins.	%	ft. in	ft. in	ft. in	°	in	ft. in	ft. in		lbs.	lb. per sq. ft.	m.p.h.	
Avis (Aeroplane S. Co.)	M	160	15	9	28 0	6 4·3		4	5·1	— 4	0 27	0	9	2 6	0	—	—	630	3·9	35	25 Anzani.
Avroplane (A. V. Roe & Co.)	T	246	74½	7	26 0	3 6	7·5	1½	3·6	3 3	6 0	24	6	4	2 8	0	3	0	·375	550	1·7	40	35 Green.
Blériot	M	193	18	5½	28 8	6	4·3	5	6·3	— 5	0	24	9	9	—	6	7	—	—	660	3·4	40	45 Anzani.
George and Jobling	B	375	38	25	30 0	5	6·5	5	5·3	5 0	4	9	30	0	9½	—	9	0	10	0	1·22	862	2·6	48	60 Green
Gregoire-Gyp (Fiat)	M	244	20	8½	34 0	7	4·4	7	4½	5·1	— 5	6	34	0	6° 40′	—	7	0	—	—	—	820	3·4	45	40 Gregoire-Gyp
Handley Page	M	150	6	6	32 6	6	5·4	2	3·5	— 6	0	20	6	6	—	6	3	6	·55	450	3·0	35	20-25 Advance
Henry Farman	B	450	27½	17	34 8	6	5·4	4½	5·8	6 0	8	8	43	0	—	—	8	0	4	0	·62	1050	2·3	55	50 Darracq
Humber, Le Blon type	M	186	12	5	29 2	6	4·3	4½	5·2	— 4	5	24	0	—	—	6	11	3	6	·5	—	—	—	30 Humber
Do. Capt. Lovelace type	M	210	16	10	33 0	6	5·4	5½	6·4	— 4	9	26	6	6½	—	11	6	11	3	2·6	·5	—	—	50	50 Humber
Do. Biplane	B	482	16	12	40 0	6	8·5	9	3½	4·4	5 0	6	33	0	6½	—	6	11	3	6	·5	—	—	50	50 Humber
Lane, 1 seater } (Lane's B.A. {	M	195	18	5½	30 0	6	6·4	6	4½	6·1	— 6	0	22	0	—	—	7	0	3	6	·5	650	3·3	30	25 N.E.C.
Do. 2 seater } Ltd.) {	M	250	25	7	32 0	7	10·4	1	7½	7·7	— 6	0	22	0	—	—	38	8	4	6	·51	970	3·9	30	60 N.E.C.
Mullines (Mullner)	M	210	14	4	33 0	6	6·5	1	3	3·9	— 4	2	27	0	10	—	6	3	4	6	·71	605	2·8	40	35 J.A.P.
Nicholson (Holland & Holland)	M	227	18	5½	32 6	7	0·4·7	5	6·0	— 4	7½	32	0	9	3 6	6	8	—	—	—	800	3·5	—	25 N.E.C.
Ornis (Lascelles)	M	160	10	5	28 0	6	0·4·7	3	4·2	— 4	6	—	—	—	90	8	0	3	0	·37	600	3·8	31	35 Lascelles
Petre (Leo Rignolt)	M	195	36	7	30 0	7	0·4·0	3½	4·2	— 4	9	29	0	—	—	7	0	3	4	·48	740	3·8	30	35 N.E.C.
Santos Dumont (A. Clement)	M	108	12	7	18 0	6	0·2·8	3	3·8	— 3	0	21	0	7	11	6	6	2	6	·38	530	4·9	40	32 Clement
Do. (Mann & Overtons)	M	128	16	6½	18 4	7	0·2·6	3½	3·9	— 3	8	20	0	—	—	6	6	—	—	—	536	4·2	45	30 Anzani
Do. (Aeroplane S. Co.)	M	143	7½	5	22 0	6	0·3·3	2½	3·5	— 4	3	26	0	—	—	6	7	3	0	·45	465	3·2	56	30 Dutheil-Chalmers
Short (1910) (Short Bros.)	B	382	55	10	31 8	5	4·6·0	3½	5·1	4 4·4	6	31	0	—	—	7	6	—	—	—	857	3·1	45	35 Green
Do. (Moore-Brabazon)	B	450	45½	7½	48 8	6	0·7·5	4	5·1	6 8	—	—	—	3	—	9	0	—	—	—	—	3·3	45	
Short Wright (Short Bros.)	B	515	84	23	41 0	6	8·6·15	—	—	6	2·5	8	29	0	—	—	8	6	—	—	—	—	—	—	
Sommer (Hon. C. S. Rolls)	B	458	45	9	34 0	6	8·5·0	4	5·0	6	0·9	0	—	—	—	—	—	—	—	—	—	—	—	—	
Spencer-Sterling (Berlict Motors)	M	200	19	6	34 0	6	0·5·6	3	4·2	— 5	0	27	0	10	17	6	6	10	0	1·6	850	4·3	40	40 R.H.
Star	M	200	20	20	42 0	8	0·5·3	4	4·2	— 5	0	32	0	8	13	6	6	3	9	·58	950	3·3	36	40 Star
Twining (Twining A. Co.)	B	252	25	6	28 0	4	6·6·1	4½	8·3	5 0	4	0	14	7	7	24	6	3	4	6	·71	450	1·8	35	20 Phœnix
Warwick Wright	M	160	14	6	27 0	6	6·4·2	4½	5·8	— 4	0	29	0	9	24	6	0	2	3	·37	605	3·8	35	40 E.N.V.
Zodiac (British & Colonial Co.)	B	475	32	10½	33 3	5	11·5·5	1·88	2·6	5 9	0	6	39	3	—	—	8	3	—	—	—	1100	2·3	35	50 Darracq

NOTES.—*Types.* B = biplane; M = monoplane; T = triplane.
Blériot monoplanes were shown by L. Blériot, Blériot, Ltd., and the Aeroplane Supply Co.

* Flight.

small a gap may be used in a biplane or triplane, but such evidence as exists, points to the conclusion that it should be approximately the same dimension as the chord, and this is common practice at the present day. Merely from a constructional point of view it would be advantageous, especially on large machines, to have a small gap, but if the gap is too small there is a loss of lifting efficiency, owing to interference between the two planes. An aeroplane sweeps downward a stratum of air of unknown dimensions, but it is supposed that the depth of the stratum, or "sweep" as Lanchester has called it, is effectively equal to the dimension of the chord (7). The stratum extends

equally above and below the aeroplane, for the air follows the contour of the upper surface just the same as it follows the contour of the lower surface. If, therefore, a biplane is made with a gap equal in dimension to the chord, it may be assumed in the light of present knowledge, or shall we say absence of knowledge, that there is no serious interference nor consequent loss of efficiency.

SKID TRACK.

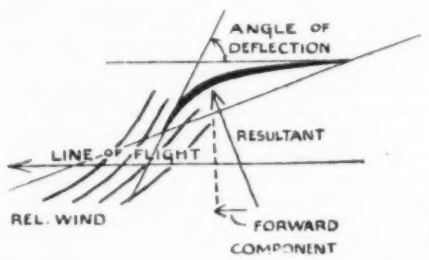
The skid track for which dimensions are given in the last column but one of those devoted to lengths is an important dimensions of an essentially practical character. It corresponds to the track of the wheels on a motor car, but with the difference that whereas the motor car is a fairly compact machine with a considerable amount of natural stability, the aeroplane is very top-heavy at the best of times and is always wanting to fall over, even on land. Too little attention has, in our opinion, been paid to this dimension in the design of several of the aeroplane chassis, but, on the other hand, there are also many examples of machines that have a good firm tread upon the earth.

The last dimension given in the column of lengths is the overall length of the machine, which, taken in conjunction with the span, indicates the approximate size of the hangar or shed that is required as a housing.

ANGLES OF INCIDENCE AND DEFLECTION.

The next series of figures relate to the angles, and have been somewhat difficult to obtain, nor do we make any great claim for their accuracy. The angle of incidence (8) is the angle that is made by the chord to the line of flight, and in modern machines it seems to have a positive value varying between 3 and 10 degrees. It is less in biplanes than in mono-

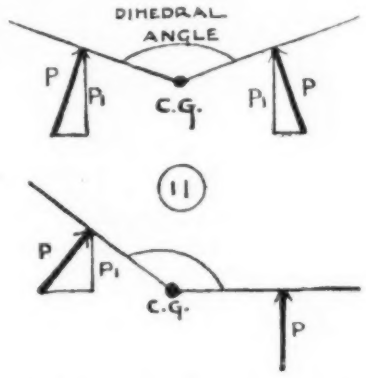
planes, owing to the relatively large area of such machines. For our own part, we are inclined to regard the present-day knowledge on this matter of the angle of incidence as being in an altogether unsatisfactory state, and we should very much welcome some really reliable data on the subject. From what we have said above about the dipping front edge, it will be observed that there is no need to have a positive angle of incidence at all, in order to get a lifting reaction from a cambered aeroplane. On the other hand it appears that some positive angle is regarded as contributing to stability, and there is reason to suppose that such is the case. It is, for instance, very instructive to bear in mind that the Wright biplanes fly with their fore and aft main spars horizontal (9),



so that the three degrees or so of positive angle of incidence is entirely obtained with the trailing portion of the plane that projects behind the aft main spar.

We have taken this opportunity of drawing particular attention to the subject, because it is likely to come in for a very considerable amount of discussion in the near future. We observe, for instance, in the model section, an exhibit, by W. F. Howard, of a monoplane designed to fly with a negative angle of incidence of the chord, in connection with which it has been sought to demonstrate a certain theory of vortex motion. We do not wish to discuss this vortex theory, but we do wish to draw attention to the fact that a negative angle of incidence to the chord is not necessarily at all the same thing as a negative angle of incidence with a flat plane.

It seems to us that the effective angle is that represented by the angle of deflection (10), that the stratum of air is caused to "bend" in order to create the lifting reaction whereby the machine is supported in flight. It is obvious that an aeroplane having a dipping front edge and a horizontal trail (10) would have its chord at a negative angle in flight. If, as the result of actual experiment, it were proved that an aeroplane were more efficient when its leading edge were dipped down so much more than its normal position that its trail became horizontal, then we should be inclined to assume this evidence primarily as an indication of the presence of an upward trend in the relative wind having a steeper slope than had been supposed. We imagine that anyone conducting such experiments would immediately increase the fore and aft dimensions of the plane in order to again deflect the trailing edge without altering the leading edge, because it would seem evident that the full opportunity for obtaining reaction by deflection of the air has not been taken if the aeroplane has a horizontal trail.



A cambered aeroplane arranged with a negative angle of chord would presumably have a resultant pressure inclined forward of the vertical, which would produce a horizontal component of thrust in the direction of flight. It must be borne in mind, however, that such a favorable force has to be paid for by engine power, and there is no particular point, so far as we can see, in utilizing the direct thrust of the propeller for the purpose of indirectly recreating another forward thrust in the aeroplane. The purpose of the propeller thrust is to overcome resistance, which is essentially a retarding force and is made up of two factors, the aerodynamic resistance that provides the vertical lift, overcoming the force of gravity, and the direct resistance represented by the skin friction of the struts, planes, and spars.

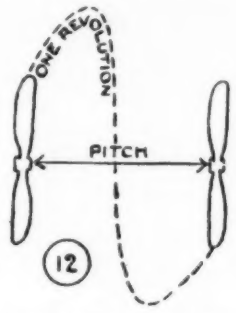
LAWS OF FLIGHT RESISTANCE.

It may be of interest while dwelling on this subject to recall the laws that govern these resistances. For a given weight supported, the aerodynamic resistance varies inversely as the square of the speed, while the head resistance varies directly as the square of the speed. The reason why the aerodynamic resistance varies inversely as the square of the speed is because the angle of incidence varies inversely as the square of the speed, and because the aerodynamic resistance is proportional to the product of the angle and the weight. In other words, if the speed of flight be doubled, the aerodynamic resistance will be reduced to a quarter of its former value.

Now it is most important to bear in mind that this law applies to aerodynamic resistance alone, and that it has no meaning whatever unless taken in conjunction with the law of direct resistance. This law, as mentioned above, states that the head resistance varies directly as the square of the speed, consequently the faster the machine flies the greater will be the power expended on this resistance.

Langley, the renowned American investigator of aerodynamics, seems to have regarded skin friction as negligible, and to have been under the impression that the inverse law relating to aerodynamic resistance could be accepted by itself; at any rate, his published statements certainly imply that the higher the speed the less the power required.

It is quite easy to understand, however, that it is only economical to reduce the aerodynamic resistance to an amount that is determined by the relative head resistance, because, when two factors obeying absolutely opposite laws have to be taken simultaneously into consideration, there is one value for each, and one value only, that produces a minimum sum in combination. The great problem that confronts the designer of an efficient aeroplane is the selection of angles, areas and dimensions of struts, so that the total re-

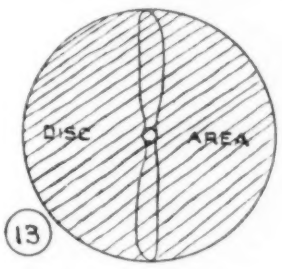


sistance of the machine in flight shall be the least possible for the load supported.

THE DIHEDRAL ANGLE PROBLEM.

Reverting again to the table, which forms the basis of our present remarks, the next column to come under consideration is that representing the dihedral angle made by the wings of many of the monoplanes. A dihedral angle is an angle made by two surfaces that do not lie in the same plane. In respect to aeroplanes, it might be described as the V-setting of the wings. Its purpose is to endow the machine with a certain amount of natural lateral stability, and the theory, or, rather, theories, associated with the dihedral angle, formed the subject of a most interesting correspondence in Flight last year. In our description of the Antoinette monoplane (Flight, vol. I, p. 662), which was the first of the monoplanes to have the dihedral angle in a very marked degree, we sought to explain the theory of natural stability associated therewith by means of simple diagrams.

These diagrams are again reproduced, and as we have seen no cause to change our original theory, we will again put forward the same explanation. The air pressure on an aeroplane is assumed to be normal, i. e., perpendicular to its surface, hence in the accompanying diagrams (11) the lines, *P*, represent the air pressures on each wing separately. These pressures are inclined from the vertical, but they produce, by the ordinary laws of component forces, two vertical components, *P*¹, that are sufficient to overcome the force of gravity and support the machine in



flight. When the machine is canted over, as shown in the lower diagram, where the right-hand wing is represented in a horizontal position, the full value of *P* acts vertically upward on the right wing, whereas the vertical components, *P*¹, of the pressure on the left wing is reduced. The values of *P*, however, are still equal to one another on both wings. Now, if the machine were pivoted upon an axis *fixed in space*, the mere fact that the two values of *P* remain unchanged would be sufficient to keep the machine in equilibrium in any position and would therefore prevent a restoration to the attitude represented in the first diagram. A flying machine, however, does *not* proceed along a *fixed axis* in space; it can rise or fall as a whole, and this fact causes the lower diagram to represent an unstable condition embodying a couple tending to restore the machine to its original attitude.

The canting of the machine has not shifted its center of gravity, C. G., which, for convenience, is assumed to be situated at the junction of the wings, and consequently it has not altered the proportion of the load carried by each wing. It will be observed, therefore, that the upward force on the right wing is superior to the load it has to carry, whereas the upward force on the left wing is inferior to its load. The result is obvious; the right wing will lift a little and the left wing fall until the loads and the lifts are again balanced. It is not necessary, nor is it probable, that this restoration of equilibrium takes place through an axis passing through the center of gravity; it is quite likely that the center of gravity falls a little through space in the operation.

In the table we have, for convenience, given the amount [illegible]dral angle as a slope of 1 in "X."

It will be noticed that there is a considerable difference in the values.

THE DIAMETER AND PITCH OF PROPELLERS.

The next series of figures in the table relates to the propeller, or tractor screw, as the case may be. A tractor screw is merely a propeller situated in front of the machine so that it pulls instead of pushes. Most monoplanes have tractor screws, and the pros and cons of the arrangement were discussed in our article on the Olympia Show last week.

The first column of figures relating to screws in the table gives the diameters of the various propellers, and it will be observed that there is not a great deal of variation in these dimensions. The next column gives the pitch, but it has not always been possible to obtain this value, owing to the fact that it can not be readily measured. The pitches given in this column are those represented by the angle of the blade. If, for instance, the pitch is given as 3 feet, it means that the machine would advance 3 feet through the air per revolution of the propeller (12), if the propeller blade were mounted in *solid* guides, so that there was no possibility of slip. The air is not solid in this way, however; it is, in fact, only capable of offering an abutment for the thrust of a propeller by virtue of being accelerated backward in the form of a rearwardly moving stream. This stream is called the "slip," and it represents a percentage (in the order of 30 per cent) of the pitch, so that the machine does not advance through the air by the full amount of the angular pitch per revolution of the propeller.

THE VALUE OF THE PITCH COEFFICIENT.

The third column of figures relating to the screws in our table gives values of the pitch coefficients, which are obtained by dividing the pitch by the diameter. In most cases it will be observed that the pitch is in the order of one-half the diameter, but that in one or two cases the pitch is greater than the diameter; in other words, the pitch coefficient exceeds unity. The pitch coefficient is a very important factor in the efficiency of a propeller, and marine experience has taught designers of propellers for that purpose that a pitch coefficient in the order of unity should be obtained even with high-speed propellers. (See Flight, vol. I, page 350.) Now it is possible in any propeller to have a pitch coefficient of unity if it is desired, but if those propellers that have a pitch coefficient less than unity in our table, were altered to have a pitch coefficient of unity, then they would either have to run at a slower rate of revolution speed or be made smaller in diameter. Those propellers that have a high pitch coefficient in our table are all indirectly driven from the engine through gear reduction mechanism.

The natural high speed of a gasoline engine does not, apparently, at the moment permit of the use of a propeller of reasonable diameter with a high pitch coefficient, and it is necessary to have a reasonable diameter in order to get sufficient disk area. The disk area of a propeller (13) is the area included in the circle described by the tips of the blades as they revolve. This disk area represents, approximately, the cross section of the slip stream; in other words, it indicates the mass of air to which rearward acceleration is being imparted. If the mass is large the velocity necessarily imparted to it in order to obtain the thrust required will be small, whereas if the disk area or diameter of the propeller is small the velocity imparted to the slip stream will be high. Now, whereas the power lost in the slip is only directly proportional to the mass of air in motion, it varies as the square of the velocity with which that mass is moving, consequently it is desirable to keep the velocity low by using a large diameter. The best proportion between mass and velocity is given, in the light of marine practice, when the pitch coefficient is unity, but in aeroplane construction the use of a direct driven propeller on a modern high-speed engine would cause the propeller diameter to be unreasonably small with such a coefficient, consequently designers have sacrificed the coefficient rather than the diameter. On monoplanes with tractor screws there is a very good reason for this, too, owing to the large amount of obstruction caused by the body of the machine. If the screw were much smaller in diameter than it is, practically its whole area would be screened in some cases.

The pitch coefficient of a propeller is a factor that indicates the limiting brake angle. If the pitch coefficient of a propeller is unity for instance, then the boss of the propeller will advance axially an amount equal to the diameter of the propeller while the tip of the blade moves through a path equal in length to the circumference. The ratio of these two movements is one to π, or approximately one to three, which ratio represents the tangent of 18 deg. This, therefore, would represent the angle made by the tip of the blade to the plane of revolution.

WEIGHT, LOADING AND SPEED.

The final series of figures contained in our table relate to weight, loading and speed. The weight given is the weight of the machine in flight and includes in every case an arbitrary allowance of 200 pounds for the pilot and fuel. Dividing the weight by the area of the main planes, we have obtained the figures given in the column of loading. These figures represent the intensity of air pressure in pounds per square foot that must be obtained upon the main planes in order to maintain horizontal flight. It has been assumed that the whole of the load is carried on the main planes, except in the case of the Roe triplane, where the tail is definitely constructed to be a load carrying surface. It is not strictly accurate to omit the supporting effect of the tail in other machines, but it is difficult to give proper value to this factor, and for convenience it was omitted altogether. It will be observed that the loading values of most of the machines are above 3 pounds per square foot, and go as high as nearly 5 pounds on the little Santos Dumont monoplane. On the Roe triplane the loading is small, owing to the large surface that is easily available with a triplane and to the lightness of construction in this particular machine. In the Twining biplane the low loading value is due to the small weight of the machine, which in turn is partly caused by the use of a light rotary engine and by the complete absence of a tail. In the Santos Dumont type of monoplane the loading value is high because of the small area. A high loading value implies that it will be necessary to fly very fast, or at a very steep angle of incidence, but the figures that we have been able to obtain relating to the speed in flight are unfortunately of such a character as to make it impossible to deduce any interesting or important conclusions by way of comparison. Much the same remarks also apply to the engine power required for flight, on which we purposely omit to make any observations.

THE FOOD SUPPLY OF THE FUTURE.*

A PROBLEM FOR AGRICULTURAL INSTITUTIONS.

BY H. P. ARMSBY.

FROM various sources we have heard of late warnings of a deficiency in the food supply of the future population of the United States.

Thus President James J. Hill in his address before the Bankers' Association, and more elaborately in his recent article in The World's Work, sets forth in striking terms the growth of our population and the present limits of wheat production and predicts a shortage of not less than 400,000,000 bushels by the middle of the present century unless radical improvements in the prevailing methods of farming are speedily inaugurated.

Davenport, in his address at the dedication of Agricultural Hall at the University of Maine, calculates that if the rate of increase of population in the past one hundred years be maintained, the end of the twentieth century will see us with a population of twelve hundred millions, and emphasizes the fact that the agriculture of the future must be enormously productive in order to feed these teeming millions. He says:

"The conditions that have just been discussed will not be temporary and transient; they will be enduring, yes, everlasting, and they must be met by a permanent agriculture—a thing the world has never yet succeeded in establishing. No race has ever yet learned to feed itself except at the expense of the fertility of its own or some other country. Other races have come up against this problem and have gone down under it. . . .

"There is to be, in the very near future, a struggle for land and the food it will produce such as the world has never yet beheld. He who knows where and how to look can see it coming. The African activity among western European nations is a part of it. It is always cheaper to move when over-population and failing fertility threaten a shortage of food—providing there is any place to move into; that is, providing we can dispossess the other party and his land is worth the contest.

"However that may be as an abstract proposition, for us there is no moving. For us there are no more "new worlds." For us there is little more "out west." Our fortune and our future, whatever they may be, are staked down on the American continent. Literally, "here we rest," and whether we like it or not, we must devise and establish a permanent agriculture or go down in the attempt."

Much the same general line of thought was followed by President J. L. Snyder in his annual address before the Association of American Agricultural Colleges and Experiment Stations, but with special emphasis on the social significance of a straitened food supply. He said:

". . . Agriculture has contributed to democracy more than we can estimate by furnishing our people with an abundant food supply. So fertile has been our land, so extensive our fields, so abundant our harvests of grain and fruit, that the best and highest grades of food have been within the reach of every citizen who has been willing to do an honest day's work. It matters not what his occupation and social position, be they ever so humble. He and his family enjoy practically the same kinds of food as that enjoyed by families of wealth and prominence. In the dinner pail of the man who works in the mill, in the mine, or digs the ditches in our city streets, can usually be found wheat bread, meat, butter, fruit, and coffee. What more does any one have? . . .

"Caste and class distinction can make little headway among a people who all live on the same kind of food. As long as the working man has in his tin pail as good a dinner as his superintendent or as the mayor of his city, his prejudices will be moderate. He will maintain his self-respect and feel and act the man. It is when the pangs of hunger begin to pinch that men give way to prejudice and passion."

After pointing out that unless the food supply keeps pace with the increase of population, there will not be enough of the better foods to go around, he says:

"The history of other countries tells us what would soon follow. Two families could not or would not occupy the same pew in church while one lived on white bread and meat and the other on black bread and potatoes. There is a social distinction there that cannot be bridged. They would not even attend the same church or belong to the same social organizations. Our people would separate into classes and become estranged from each other. The power usually goes with wealth, but the men compelled to live on cheap food would soon get into the same political party and perhaps gain control of the national government."

and quotes from a letter of Lord Macauley to an American friend as follows:

". . . The day will come when the multitudes of people, none of whom has had more than half a breakfast or expects to have more than half a one will chose a legislature. Is it possible to doubt what sort of a legislature will be chosen? . . . There will be, I fear, spoliation. The spoliation will increase the distress; the distress will produce fresh spoliation. . . . Either civilization or liberty will perish."

Even if we question the estimates of rate of increase in population on which these warnings are based, and however much weight we may attach on the other hand to estimates of increasing agricultural production per acre, it would be foolish in the extreme to close our eyes to the fact that the intensity of the demand for food by our future population will exceed anything we have yet known. Whether this state of affairs is to come about more or less rapidly is important chiefly as it gives us more or less time to prepare for it.

This is not the occasion to discuss problems of crop production nor of the conservation of soil fertility, but there are other aspects of the question which intimately concern us as stock feeders.

The problem of food supply is essentially a problem of energy supply. While a small proportion of our food during the earlier years of life serves to build up the bodily machinery, by far the larger part of it is simply the vehicle by means of which chemical energy is introduced into an organism, to be liberated again as work or heat in the performance of the vital functions. Briefly and crudely stated, the food

*Presidential address delivered before the American Society of Animal Nutrition at Chicago, Ill.

is the fuel of the body. The ultimate source of this energy, so far as we are concerned, is the sun. Crops are produced by means of solar radiation and food represents the stored-up energy of the sun's rays. The continuance of life upon the earth is conditioned upon the ability of the plant to effect this storage of energy, and the density of population which a country can support from its own resources is limited absolutely by the amount of solar energy which can be recovered in the form of food products.

In view of this absolute dependence on solar radiation, it is a rather startling fact that the larger part of the energy stored in an acre of crop is contained in inedible products. From one-half to two-thirds of the organic matter of the corn crop, for example, is contained in the stover and cobs, and about sixty per cent of that of the average wheat crop in the straw. Furthermore, grain itself is not adapted for direct consumption by man, but undergoes various processes of preparation, giving rise to numerous unavailable by-products. For example, in the milling of wheat, about 25 per cent of the grain passes into the offals, and only 75 per cent serves for purposes of human nutrition. In other words, out of the total energy stored up by the growth of an acre of wheat only about 30 per cent serves directly for the nutrition of man. Substantially the same thing is true in greater or less degree of other food crops, while the grasses and leguminous forage crops which play so important a role in modern agriculture are, of course, entirely useless as human food.

It is clear that as population becomes denser and agriculture more intensive, it will become essential to utilize the energy of these by-products as completely as possible. When we number 500,000,000 we cannot afford to throw 60 per cent of the energy of the wheat crop into the manure heap if it is possible to save any of it. The agency for effecting this saving is our domestic animals. They are able to consume these by-product materials which man cannot use and to render available a portion of their energy, using it in the first instance to support their own lives, but also storing up for man's use a certain part of what would otherwise be a total waste. As the demand for food grows more intense, it will become increasingly important to so husband these by-products and combine them into efficient rations, and to feed these rations under such conditions and to such types of animals, as to save the largest possible percentage of the energy which they contain.

It scarcely need be said that we are still far from doing this. Our rations are too often faulty and fed to inferior animals under unfavorable conditions, and only a short railway journey is necessary to convince one of the enormous waste of forage taking place every year, while our by-product feeding stuffs compete with native products in the markets of the old world.

With our relatively sparse population, this has hitherto been a country not only of cheap food, but especially of cheap meat, and we have been fond of drawing the contrast between the diet of our laborers, with its abundance of animal food, and that of the European laborer, and whether rightly or wrongly, have attributed much of the greater efficiency of our workmen to this difference in diet. This abundant meat supply has been drawn especially from the vast corn fields of the Mississippi valley. Not only have our by-products gone to waste, but material available as human food has been converted into meat and milk. While this concentration of grain into higher priced and more marketable products has been in the past and to a degree still is entirely justified economically, nevertheless, the conversion of corn, or of any food grain, into meat is an exceedingly wasteful process. Jordan* computes that in the production of beef or mutton only about 2 2/3 per cent of the digestible organic matter consumed by the animal is recovered as human food in the edible portion of the carcass, while even in pork production this percentage rises to only about 15½ per cent. Facts like these make it evident that we can not continue indefinitely to use edible grains as stock food—to take the children's bread and cast it to the beasts. The waste of energy in the transformation is too great. Nor is it any answer to say that wheat and not corn is the bread grain of the western world. The irresistible economic pressure of population will sooner or later compel us either to use corn as human food or to utilize the land now devoted to corn culture for other crops which shall yield more available nutriment, while the stockman will be forced to utilize by-product feeds to the utmost, not simply as a means of continuing meat as a prominent ingredient of our diet nor of providing animal foods as luxuries for the tables of the wealthy, but primarily as a means of conserving energy for human use. The feeder of the future will utilize by-product feeds to an extent as yet unrealized. He will pass in review the crude products of the farm, and all the hundred and one wastes of manufacturing operations, to see if perchance they still contain energy which he can extract. Like the miner, he will be ready to work low-grade ore, provided there is a sufficient margin of profit. Even the small amounts of available energy contained in such feeds as oat hulls, corn and the like will be utilized and their waste energy saved as rapidly and as far as economic conditions render profitable, and to aid in rendering this possible is to render service to mankind.

It must be clearly understood, however, that this desirable end is not to be attained by any species of pious fraud. The manufacturers of mixed feeds are of late making much of the importance of by-product materials, a most sound proposition in itself, but one which hardly justifies all the corollaries which some of them appear to draw from it. That corn cobs, for example, contain a certain small amount of available energy does not render it an act of benevolence to induce the farmer to feed them, as Mike wanted his whiskey supplied, "unbeknownst," in some fixed feed with a high-sounding name or as an inconspicuous admixture to some well-known material. Such surreptitious kindness is in danger, in the long run, of recoiling upon its author. We shall not effect the needed economies of the future by coaxing or beguiling the feeder into utilizing these low-grade materials as ingredients of patent feeds or pre-digested mixtures or ready-balanced rations, but by teaching him their true value and educating him to make his own mixtures and balance his own rations. Personally, I am opposed on principle to mixed feeds, as I am to mixed fertilizers, not because many of them are not good of their kind, but for the reason that they minimize the intelligence of the farmer while they open a wide door for fraud on the part of unscrupulous manufacturers and dealers.

The questions which we have been considering are very broad ones. They signify nothing less than a revolution, no less real because gradual, in the methods of agriculture as a whole and of the production of animal foods in particular, and the conditions which we must expect in the future will call for a much higher degree of skill in adapting means to ends than has been necessary in the past. What, then, should be the attitude of the institutions for agricultural teaching and research toward the problem of the future food supply?

Hitherto a large share of our experiments in feeding have had for their chief aim the improvement of present practices. They have sought to demonstrate how we may most efficiently convert grain into meat rather than how much of it can be saved for man's direct use. While such experiments have been of undoubted immediate utility, yet we shall soon have to reverse the point of view. Our experiment stations must take up in earnest the conservation rather than the exploitation of food resources, and our agricultural colleges, while still teaching the approved practices of the present, must as their chief aim seek to equip their students with a sound knowledge of underlying facts and laws and thus prepare them to meet the changing conditions of the future. In passing, too, I can not forbear calling attention to the fact that such an attitude toward the subject of animal husbandry and such methods of teaching it will serve to impart to it a higher pedagogic value than it generally has at present and will tend to make it a disciplinary as well as an informational subject.

Investigation of the questions here outlined must be of as broad and comprehensive a character as the problems to be solved. It should proceed, as I view it, along two main lines.

The first of these is a far more extensive and profound study of the scientific principles of animal nutrition than has yet been made.

That he may utilize the materials of which I have been speaking as completely as possible, the stockman needs to know in the first place what proportion of the energy which these various materials contain it is possible or practicable to recover. This knowledge will enable him to effect a wise selection in the compounding of rations, as well as to have an influence upon the whole system of farming. In the second place, he needs to know the relative efficiency of different species, breeds and types of animals as converters of energy and how their efficiency is influenced by their natural or artificial environment.

These, however, are questions of animal physiology. In effect they ask how does the animal mechanism operate when supplied with different raw materials or placed under varying conditions. They are problems for rigorous scientific research and too much stress can not be laid upon the importance of such research. A well-known investigator, in a private communication from which I am permitted to quote, says:

"If we are to find new things, to get new ideas and to establish new lines of practical experimentation, we must first increase our field of opportunity by discovering new facts of general application. The progress of every branch of applied science has been made in this way and agriculture as well as the mechanic arts has shared in the benefits. The immense improvements of recent years in agricultural practice are largely founded on the purely scientific investigation of the preceding generation. The progress of the future must be founded on the scientific research of the present. That researches directed to immediate practical results frequently fail to yield all that may be expected of them is largely due to the imperfections of the scientific work of the past and so makes evident the importance of undertaking in the present purely scientific studies which will lead to more definite and valuable results when future experiments are directed to the solution of practical problems.

"No field of study opens so widely or presents so many opportunities for gaining knowledge of untold practical importance as that of animal nutrition.

"As an illustration of the importance of gaining information respecting the fundamental problems of nutrition, the knowledge gained during the last few years respecting the constitution of the proteins may be mentioned.

"As a result of these recent discoveries the whole question of protein assimilation is put in an entirely new light, multitudes of new questions are raised which must be answered before the feeding of these substances can be carried out on a scientific and intelligent basis. Heretofore in conducting feeding experiments proteins have been assumed to be of equal nutritive value and no definite evidence has been obtained which shows whether or not this is so. The wide differences in the constitution of the proteins of different animal and vegetable tissues at once raises the question of their relative nutritive value and the best methods of feeding them. Definite information respecting the nutritive value of each of the proteins commonly employed for food can not fail to show the way to new experiments with the use of commercial feeding stuffs and ought sooner or later to show the way to more productive and economical uses of these foodstuffs. A similar knowledge of the actual nutritive relations of phosphorus-containing substances* would likewise doubtless lead to similarly important results and deserves far more attention from a purely scientific standpoint than it has yet received.

"Concerning all these questions we know something, but how little this is in comparison with what remains to be discovered. These are hard problems but they must be solved, before agricultural practice can have the benefit of what science can do for it."

Such work is intensely individual in character. The prime factor is the man. The principal service, and a highly important one, which an organization can render is to aid in providing the opportunity. Such service I earnestly hope our society may be able to perform, especially in the direction of impressing upon public sentiment as represented in legislative bodies, on the one hand, and upon the minds of benevolent men of wealth, on the other hand, the fundamental importance of scientific research for the successful solution of the problem of the future food supply.

The other main line of experimental effort relates to the economic application in practice of the principles discovered by scientific investigation. Along this line, as I see it, there is a wide field open for fruitful experimental work, but this aspect of the subject was so fully dealt with last year in the report of the committee on organization that it seems superfluous to enter into it anew at this time.

Finally, along both lines of effort, but especially the second, there should be a co-ordination of effort and of spirit combined with the largest possible scope for individual initiative. This society owes its origin largely to a feeling of dissatisfaction over the more or less fragmentary and elementary nature of our past work. The discussions of the Cornell conference and of the last annual meeting of the society, as well as the incorporation into its constitution of the provision for a committee on experiments, clearly shows a desire on the part of investigators for closer relations with each other and a more broadly conceived program of investigation. It is hoped that the meetings of this society and the work of its committee may at least be serviceable in defining problems and improving methods.

But no program of agricultural investigation can be truly national in its scope which does not include the greatest agricultural agency perhaps in the world—certainly the predominant one in this country—the United States Department of Agriculture. No one would think of intimating that this great department has neglected the interests of the stockmen of the United States, but nevertheless, it is true that until very recently its work for them has been chiefly of the nature of veterinary and inspection work, as indeed it still is to a relatively large extent. The Bureau of Animal Industry has, it is true, established a dairy division and has begun to take up problems of feed-

*"The Feeding of Animals," 5th edition, p. 405.

*The experiments of McCollum, at the Wisconsin station, published since this was written, are most important on this point.

ing and especially of breeding with the modest appropriation for this purpose which Congress has put at its disposal. The department should be put in position to do much more than it is doing, however. Its work in this field should be productive as well as protective. If the development of our waterways and the conservation of our forests, mines and water powers are subjects of national concern, surely the conservation of the food supply is worthy of attention. The magnitude of the live stock industry in itself, and especially its important relations to the future food supply of the nation which I have been endeavoring to point out, are such as to amply warrant the department in entering upon comprehensive investigations, both scientific and practical, into this subject and to fully justify Congress in making all necessary appropriations. It is not alone our food supply, but our democracy, which is at stake.

It goes without saying that such an effort on the part of the national government should be made in harmony with the investigations which may be undertaken by other agencies. All the available forces should unite in the study of these important questions and no local jealousies should be allowed to stand in the way. While there may be problems of co-ordination and correlation still to be solved, I am confident that they are readily solvable, while it seems not impossible that in some respects this society might advantageously serve as an unofficial intermediary between state and national authorities.

I congratulate the society upon the notable increase in its membership during the past year and upon the very encouraging attendance upon its first annual meeting. If I understand the spirit and temper of its members, they desire to make the society something more than a pleasant club or a gathering for the reading of papers. It is my hope, which I believe I share with every member, that it may become an active agency in forwarding the solution of some of the problems which I have attempted to indicate in this address.

In an article published in the Phys. Zeitschrift, W. Krebs discusses the dimensions of the earth's nucleus. The periods of 33, 60, and 24 minutes found in seismograms are discussed. Oddone considers 33 and 60 minutes to be the times taken by the first and second phase waves to travel to the antipodes and back, i. e., a distance of two terrestrial diameters. Krebs regards the 24 minute as the time taken by the preliminary tremors to travel through the earth's nucleus to its antipodal boundary and to return after reflection there. He thus obtains 9,850 or 10,026 kilometers as the diameter of the nucleus according as he adopts Wiechert's or Benndorf's value for the velocity of propagation in the nucleus relative to that in the crust.

ENGINEERING NOTES.

Before the International Association for Testing Materials, L. Guillet and L. Revillon read a paper on impact tests at variable temperatures. Reference is first made to the work of Charpy, who found that resilience, i. e., the specific work done in fracture—first increased as the temperature rose to 150 deg. C. and decreased afterwards, reaching a minimum between 400 deg. and 500 deg. Tests have been carried out with a view to investigating blue-heat brittleness, on carbon steels of increasing carbon content, nickel steels and one nickel-chrome steel. The specimens were broken in a Guillery machine on an anvil with a 1-57-inch opening, and with an initial energy of 434 feet-pounds. The results showed that the resistance to shock increased up to a temperature of 200 deg. C. when it fell gradually, to increase again when the steel was red-hot. The temperature of maximum fragility was always the same and equal to 475 deg. C., a red-glow temperature. This is not the so-called blue heat, 300-325 deg. C. There was a maximum resilience, less fixed, at 150 deg. to 200 deg. C., depending on the nature of the steel; at this temperature all the specimens showed a strength of at least 72 feet-pounds. For one of the most brittle steels 36 feet-pounds was obtained in the cold, and 72 feet-pounds at 200 deg. C. The minimum resilience observed at 475 deg. C. was below the value observed at ordinary temperatures; the difference amounted to 43-50 feet-pounds, and this decrease was the greater the softer the steel. For nickel steels the figures were 180 feet-pounds at ordinary temperature, and 87 at 475 deg. C. Nickel-chrome steel showed a marked constancy: 115 feet-pounds in the cold, and the same at the minimum, and the curve ascended very slowly beyond the minimum. The results do not account for the fact that a soft-steel sheet can be broken at a blue heat.

The character of coal in relation to smoke prevention was the subject of a paper read by Mr. D. T. Randall before the Syracuse meeting of the National Association for the Prevention of Smoke. Mr. Randall stated that the semi-bituminous coals, which are the most extensively used for steam generation, require especially designed furnaces and careful operation to obtain good results. The volatile matters from such coals are set free more readily than from other types of coal, and in the case of some bituminous coals the volatile matter given off on heating is exceptionally difficult to burn. Smoke is an indication of incomplete combustion, and its reduction is important to the fuel user, since much potential heat may escape with the unconsumed gases present in the smoke. A table is given from the U. S. Geological Survey Bulletin, No. 325, showing that the percentage of CO in the exit gases increases with the percentage of black smoke. The losses of heat due to the presence of this gas and of hydrogen in the exit gases from the boilers vary from 1 to 10 per cent, and are always a feature of a smoky chimney. In order to obtain perfect combustion of the gases given off by bituminous coals, a high temperature, an adequate supply of heated air, and a large combustion space are required. In most plants the gases pass from the fuel bed to the top of the chimney in 10 to 15 seconds, and therefore the gases must pass through and away from the combustion chamber in 1 second. At the end of this brief period, therefore, combustion must be complete. This fact makes clear the necessity for a sufficient air supply, properly distributed, and for an ample combustion space above or at the back of the grate. A good furnace should permit the burning of bituminous coal in sufficient quantities, without loss by escaping CO or hydrogen gas, when the air supply is about 50 per cent in excess of the theoretical amount. It has been found by experience that mechanical stokers, with a coking plate, can best provide the essential conditions requisite for the complete combustion of these coals. A furnace suitable for one class of coal may, however, be entirely unsuited for others, and a careful study of all factors named above is required, in order to design a furnace which shall be smokeless and economical with the particular fuel selected for use.

TRADE NOTES AND FORMULÆ.

Varnish for Securing Transfer Pictures to Earthenware Goods.—13 parts of mastic, white rosin 25 parts, Venice turpentine 54 parts, sandarac 50 parts, 98-degree alcohol 160 parts, dissolved at a moderate heat.

Cleansing Medium for Gilded, Bronzed, and Similar Articles.—A mixture of 10 parts burned alum and 30 parts of soda lye, with 500 parts of water, with which about 7 parts of celluloid varnish is intimately mixed. This is the substance of an Austrian patent application.

Production of Pure Caseine.—Allow milk to stand in a cool place and very carefully remove the cream. The skimmed milk is coagulated in a warm place. To determine its perfect coagulation, a portion of the fluid, separated from caseine, is treated with hydrochloric acid; if a precipitate results, there is still caseine in solution and about half a per cent of hydrochloric acid is added to the entire quantity of coagulated milk. After coagulation the thoroughly whipped mass is transferred to a paper filter, the fluid allowed to drain off thoroughly and the caseine remaining on the filter washed with rainwater until the water running off no longer displays a trace of free acid. To remove the last residue of fat, boil the drained caseine, which has been tied up in a cloth, in water, spread it on blotting paper and allow it to dry in a warm place, when it will shrivel up into a horny mass.

Thickening for Mineral Lubricating Oils.—According to Marquardt, aluminium sebate makes a thickening for mineral lubricating oils. A 10 per cent solution of this substance in mineral lubricating oil produces a brown, tolerably consistent mass, capable of being drawn out in threads and difficult of fusion, and known in commerce by the name of "liquid gelatine," though containing no trace of gelatine. It causes the mineral oil to froth when used, and clogs the parts of the machine by setting free the alumina soap, especially when water is present. If such mineral oil is shaken up with 95 per cent alcohol, and ether carefully added to it, the aluminium sebate is precipitated, first in flakes and then in lumps, but it is redissolved in an excess. The ash content of pure mineral oil does not exceed 0.058 per cent; soda lye does not eliminate the alumina completely, but the exact quantity eliminated can be accurately determined by the following process: If heated in a water bath with constant stirring, diluted hydrochloric acid will remove all the alumina; soda lye will then absorb the fatty acids from the separated mineral oil, and these fatty acids can in their turn be precipitated with a mineral acid and their weight determined. The difference between the weight of a mineral oil eliminated from the alkaline solution by means of a separating funnel and the original weight is equivalent to the quantity of fatty acid anhydrides and alumina found.

Alcohol

Its Manufacture
Its Denaturization
Its Industrial Use

The Cost of Manufacturing Denaturized Alcohol in Germany and German Methods of Denaturation are discussed by Consul-General Frank H. Mason in SCIENTIFIC AMERICAN SUPPLEMENT 1550.

The Use, Cost and Efficiency of Alcohol as a Fuel for Gas Engines are ably explained by H. Diederichs in SCIENTIFIC AMERICAN SUPPLEMENT 1596. Many clear diagrams accompany the text. The article considers the fuel value and physical properties of alcohol, and gives details of the alcohol engine, wherever they may be different from those of a gasoline or crude oil motor.

In SCIENTIFIC AMERICAN SUPPLEMENT 1581 the **Production of Industrial Alcohol and its Use in Explosive Motors** are treated at length, valuable statistics being given of the cost of manufacturing alcohol from farm products and using it in engines.

French Methods of Denaturation constitute the subject of a good article published in SCIENTIFIC AMERICAN SUPPLEMENT 1599.

How Industrial Alcohol Is Made and Used is told very fully and clearly in No. 3, Vol. 95, of SCIENTIFIC AMERICAN.

The Most Complete Treatise on the **Modern Manufacture of Alcohol,** explaining thoroughly the chemical principles which underlie the process without too many wearisome technical phrases, and describing and illustrating all the apparatus required in an alcohol plant, is published in SCIENTIFIC AMERICAN SUPPLEMENTS 1603, 1604 and 1605. The article is by L. Baudry de Saunier, the well-known French authority.

In SUPPLEMENTS 1607, 1608, 1609 we publish **a digest of the rules and regulations** under which the U. S. Internal Revenue will permit the manufacture and denaturation of tax free alcohol.

A Comparison of the **Use of Alcohol and Gasoline in Farm Engines** is given in SCIENTIFIC AMERICAN SUPPLEMENTS 1634 and 1635 by Prof. Charles E. Lucke and S. M. Woodward.

The Manufacture, Denaturing and the Technical and Chemical Utilization of Alcohol is ably discussed in the SCIENTIFIC AMERICAN SUPPLEMENTS 1613 and 1636 by M. Klar and F. H. Meyer, both experts in the chemistry and distillation of alcohol. Illustrations of stills and plants accompany the text.

The Source of Industrial Alcohol, that is the Farm Products from which alcohol is distilled, are enumerated by Dr. H. W. Wiley in SCIENTIFIC AMERICAN SUPPLEMENTS 1611 and 1612 and their relative alcohol content compared.

The Distillation and Rectification of Alcohol is the title of a splendid article by the late Max Maercker (the greatest authority on alcohol), published in SCIENTIFIC AMERICAN SUPPLEMENTS 1627 and 1628. Diagrams of the various types of stills in common use are used as illustrations.

In SCIENTIFIC AMERICAN SUPPLEMENT 1613 the **Uses of Industrial Alcohol in the Arts and in the Home are discussed.**

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TABLE OF CONTENTS.

PAGE

I. AERONAUTICS.—Table of Aeroplanes at Olympia.—Some Observations on the Theories of Flight.—14 illustrations. 300

II. ARCHEOLOGY.—New Finds in the North African Region.—By the Paris Correspondent.—16 illustrations. 296

Chemistry and Archeology. 297

III. ASTRONOMY.—Where to Find the Stars, a Link Between the Maps and the Sky.—By F. R. Russell. 298

IV. CHEMISTRY.—Formation of Ozone by the Action of Ultra-Violet Rays. 298

V. ECONOMICS.—The Food Supply of the Future.—By H. P. Armsby. 301

VI. NAVAL ARCHITECTURE.—The Battleship of the Future.—By Rear Admiral R. H. S. Bacon, C.V.O., D.S.O., Associate. 294

VII. PHYSICS.—Theories of Impact. 295

VIII. TECHNOLOGY.—The Principles of Vitreous Enamelling of Cast-Iron for Industrial Purposes.—By Harold Holcroft, M.A., F.R.P.S. 299

Modern Stereotypy, and The Mechanics of the Newspaper.—11.

—By Henry A. Wise Wood.—3 illustrations. 302

Artificial Fabrics. 304